lake winnipeg, churchill & nelson rivers study board CANADA MANITOBA 1971-'75

biophysical, forestry and geological studies

technical report appendix 3

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

APPENDIX 3 - BIOPHYSICAL, FORESTRY AND GEOLOGICAL STUDIES

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B - FOREST RESOURCE INVENTORY OF: THE AREA BETWEEN THE 715-FOOT ELEVATION CONTOUR AND THE WEST CHANNEL AND THE AREA TO BE EXCAVATED FOR 2-MILE, 8-MILE AND OMINAWIN BYPASS CHANNELS

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BIO-PHYSICAL LAND INVENTORY
OF THE
CHURCHILL-NELSON RIVERS STUDY AREA
NORTH-CENTRAL MANITOBA

by

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June, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

ACKNOWLEDGEMENTS

This BIO-PHYSICAL LAND INVENTORY was conducted by the Canada-Manitoba Soil Survey. The project was funded through a Lake Winnipeg, Churchill and Nelson Rivers Study Board grant administered by The University of Manitoba.

Sincerest thanks are extended to Mr. A. Alkier for assistance in field checking and sampling; Dr. R.E. Longton, Department of Botany, University of Manitoba, who assisted in the identification of plant specimens; Mr. P. Haluschak, Canada-Manitoba Soil Survey, who supervised the analyses of soil samples; and to Messrs. R. DePape, N. Lindberg, and J. Griffiths, for drafting of the bio-physical maps and the report diagrams.

The assistance of Miss B.E. Stupak and Miss B. Boyle in the preparation of the report is also gratefully acknowledged.

NOTE:

Maps and site specific information is not included in this report but may be obtained on request from the

Canada-Manitoba Soil Survey,
Food and Soil Science Building, University of Manitoba, Fort Garry Campus.

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I. ABSTRACT

A bio-physical land inventory was conducted in north-central Manitoba to provide basic data on the nature and form of surficial deposits, soils, vegetation, and water bodies in a manner suitable for the interpretation or evaluation of land for forestry, wildlife, recreation, and engineering. The area designated for land inventory consisted of three major areas in the Churchill-Nelson Rivers system, which were expected to be affected by man-made changes in water levels.

The collection of terrain, vegetation, and water body information was done by a team consisting of two pedologists and two forest ecologists. The information gathered at representative and ecologically - significant sites included: identification and description of surficial deposits; description of vegetation communities and vegetation history; and identification, description and sampling of soil profiles. In addition to this, the team also concerned itself with:

1. The nature and occurrence of permafrost in organic and mineral deposits;
2. The nature of surface drainage patterns;
3. The size, shape, and shoreline attributes of water bodies;
4. The collection of relevant meteorological data;
5. The chemical and physical analysis of soil samples;
6. The compilation of suitable land type maps for use by other study sectors.

The inventory resulted in the compilation of three Land System maps, one for each project area, at a scale of 1: 250,000. In addition, 7 Land Type maps were compiled at a scale of 1: 50,000, and 82 soil profiles were analysed for their physical and chemical properties.

The survey areas, particularly the Southern Indian Lake and Rat-Burntwood Rivers areas, were found to have a relatively fragile ecological balance owing to the discontinuous presence of permafrost, the slow rate of vegetative growth, and the predominance of stratified lacustrine deposits. The silt-textured laminae of these deposits were found highly susceptible to water erosion, and had a low permeability and a high liquifaction potential. In addition, the extensive organic deposits of the survey areas were found to have a high potential for lake eutrification.

II. SUMMARY AND CONCLUSIONS

A bio-physical land inventory has been conducted in the Churchill-Nelson Rivers study area. This area is located in the Province of Manitoba between the 53° and the 58° parallel, and the 96° and 100° meridian.

The study area has a continental climate, characterized by short, cool summers and long, cold winters. Mean annual ranges of temperature are very large; being of the order of 70° to 75° F. The mean annual temperature of the area is less than 32° F. Precipitation is moderate to light; the mean annual amount ranging between 16 and 18 inches. Approximately two-thirds of the precipitation occurs in the summer months.

The terrain of the study area varies from very weakly to moderately broken. Very weakly to weakly broken terrain predominates and occurs discontinuously throughout the area. The areas of moderately broken terrain are found primarily in the vicinity of the settlements of Cross Lake and South Indian Lake as well as in the lower reach area of the Rat river system. This terrain generally consists of exposed bedrock or is bedrock-controlled.

Lacustrine materials are the dominant deposits of the study area. These deposits generally consist of relatively homogeneous clay-size materials in the Outlet Lakes project area. However, the lacustrine deposits in the Rat-Burntwood Rivers and Southern Indian Lake project areas consist mainly of stratified silts and clays. The topography of lacustrine terrain is often bedrock controlled. Low relief, depressional lacustrine terrain is characterized by organic accumulations. These peat deposits are very extensive in the study area. They consist of Sphagnum moss peat, forest peat, or fen peat, or a combination of these materials. The thickness of such peat deposits may exceed ten feet. Glacio-fluvial deposits of sands and gravels are found throughout the area; although, their occurrence is rather infrequent. Calcareous, loam-to clay-loam glacial till deposits are present in minor amounts in the north-eastern portion of the Southern Indian Lake project area. Glacier-modified lacustrine clay deposits occur in the southern portion of the Outlet Lakes project area. Acid, loam-textured till deposits are found along the western edge of the study area and occur usually at elevations greater than 1,000 feet above mean sea level.

Permafrost occurs throughout the study area, but varies in thickness and extent. The Southern Indian Lake project area is situated in the region of discontinous permafrost. Average thickness of the permafrost in this area is about 55 feet. Processes of cryoturbation are active in this region as evidenced from the common occurrence of soil hummocks. The remainder of the study area is in the region of localized permafrost. Thickness of permafrost in this region varies from about 50 feet at its northern limit to less than 1 foot at the southern one. The thickness of the active layer varies from less than 2 feet to greater than 4 feet, depending on soil and topographic conditions. In general, the ice content is less than 50 per cent in mineral materials and greater than 65 per cent in organic accumulations.

Soil development in the study area varies considerably, depending mainly on the nature of the parent material and the presence or absence of permafrost and/or cryoturbation. In general, soils classified as Gray Luvisols predominate on moderately-well drained lacustrine deposits. Brunisolic soil development is normally associated with the glacio-fluvial materials. Regosolic soils are found on disturbed glacio-fluvial deposits and on very strongly calcareous lacustrine sediments, which may be cryoturbated. Gleysolic and, particularly, Organic soils are found in the poorly to very poorly drained landscape positions. The Organic soils present belong primarily to the Mesisol great soil group; Fibrisols and Humisols being less extensive. Gleysolic soils in the southern part of the study area are mostly Rego Gleysols, while Low Humic Eluviated Gleysols and even Humic Eluviated Gleysols occur in the northern-most part. All the soils present may contain permafrost. The active layer in soils with thick organic surface horizons is generally about 18 inches thick, but varies greatly in soils that have thin or lack organic surface horizons.

Vegetation occurring on mesic sites in the study are is dominated by black spruce forests; excepting the mixed forests occurring near the southern boundary. On going from north to south, the black spruce forests change from an open forest with a ground vegetation of lichen and low prostrate shrubs to a closed forest with a continuous ground cover of mosses. Tamarack is the most important tree of subseral communities in the northern part of the study are while jack pine is most important in the southern part. Saturated sites have muskeg (black spruce) and bog vegetation.

Relatively unaltered materials of the study areaare more susceptible to water erosion than similar materials affected by soil formation. Clay-textured materials are least susceptible to water erosion. Runoff water on sloping mineral deposits normally will result in sheet erosion but is likely to accentuate gully erosion on terrain having a hummocky microrelief. Wave action on unaltered lacustrine deposits causes soilfall or sliding in stratified deposits and slumping in clay-textured materials.

In general, field permeabilities of the relatively unaltered lacustrine deposits are estimated to be less than 2.0 inches per hour. This estimate should be decreased when dealing with stratified lacustrine deposits. Structural changes, occuring in altered soil materials, should increase the permeability estimates.

Engineering test data show that plasticity and shrink-swell potential highest for materials classified as clay. Some of these clay-textured materials are in a finely divided state, as indicated by the high plastic limit and low plasticity index. In general, materials affected by soil formation have a higher shrink-swell potential and lower plasticity index than their unaltered material. Liquid limits are lowest for silt-textured lacustrine deposits, occurring at a moisture content between 15 and 20 per cent.

The eutrification potential of soil materials, as measured by extraction of soil phosphorus with bicarbonate,is highest for organic materials and mineral materials having high organic carbon contents. In general, the eutrification potential decreases with increase in depth and with decrease in degree of alteration of the material.

From the foregoing information the following conclusions and recommendations have been derived:

1. The environmental conditions of the study area are comparable to those of that portion of the Mackenzie River valley situated between Fort Vermillion, Alberta, and the 64° parallel; approximately midway between Wrigley and Fort Norman, N.W.T.
2. The regional vegetation primarily reflects climatic and, to a lesser extent, topographic conditions. Soil and parent material have a local affect on vegetation as evidenced from growth and density data as well as species variability. In general, the growth rate of tree species decreases with increase in latitude.
3. Lacustrine materials are the dominant surficial deposit of the study area. The stratified lacustrine deposits, which predominate in the Rat-Burntwood Rivers and Southern Indian Lake project areas, are highly sensitive to environmental disturbance owing to the high erodibility, low permeability, and high liquifaction potential of the silt-textured laminae.
4. All materials in the northern half of the study area, excepting well drained glacio-fluvial deposits, are highly sensitive to those disturbances which affect the energy balance of the permafrost.
5. Maintenance of an organic cover on mineral materials is essential for preventing sheet and gully erosion as well as the melting of permafrost.
6. Land flooding should seriously affect the nutrient balance in the lakes and rivers as the mildly alkaline water is expected to extract large

quantities of phosphorus, in particular, from the extensive organic deposits.

7. The relatively fragile balance in the environment of the study area necessitates due caution and concern in management decisions and practices.

III. COMPREHENSIVE REPORT

INTRODUCTION

A bio-physical land inventory was conducted in the Outlet Lakes, Rat-Burntwood Rivers, and Southern Indian Lake areas. The aim of the survey was to obtain information on the physiography, surficial deposits, soils, and vegetation of these areas in order to differentiate and classify ecologically-significant segments of the land surface. This inventory is expected to serve as the ecological basis for land-use planning involving future management of lands for water, recreation, fisheries, wildlife, and forestry.

Approximately 9 million acres were covered by this bio-physical land inventory. Rapid coverage of such a large area required extensive use of aerial photographs and air photo interpretation techniques combined with limited ground truthing. By using this approach, emphasis was placed on the classification and mapping of patterns of soil, landform, vegetation, and water.

The areas investigated are illustrated in Figure 1. Generally speaking, they extend from the northern tip of Lake Winnipeg at latitude N53° 51' northward to the vicinity of the 58th parallel. This area comprises a large portion of the area in North-Central Manitoba originally covered by glacial Lake Agassiz.

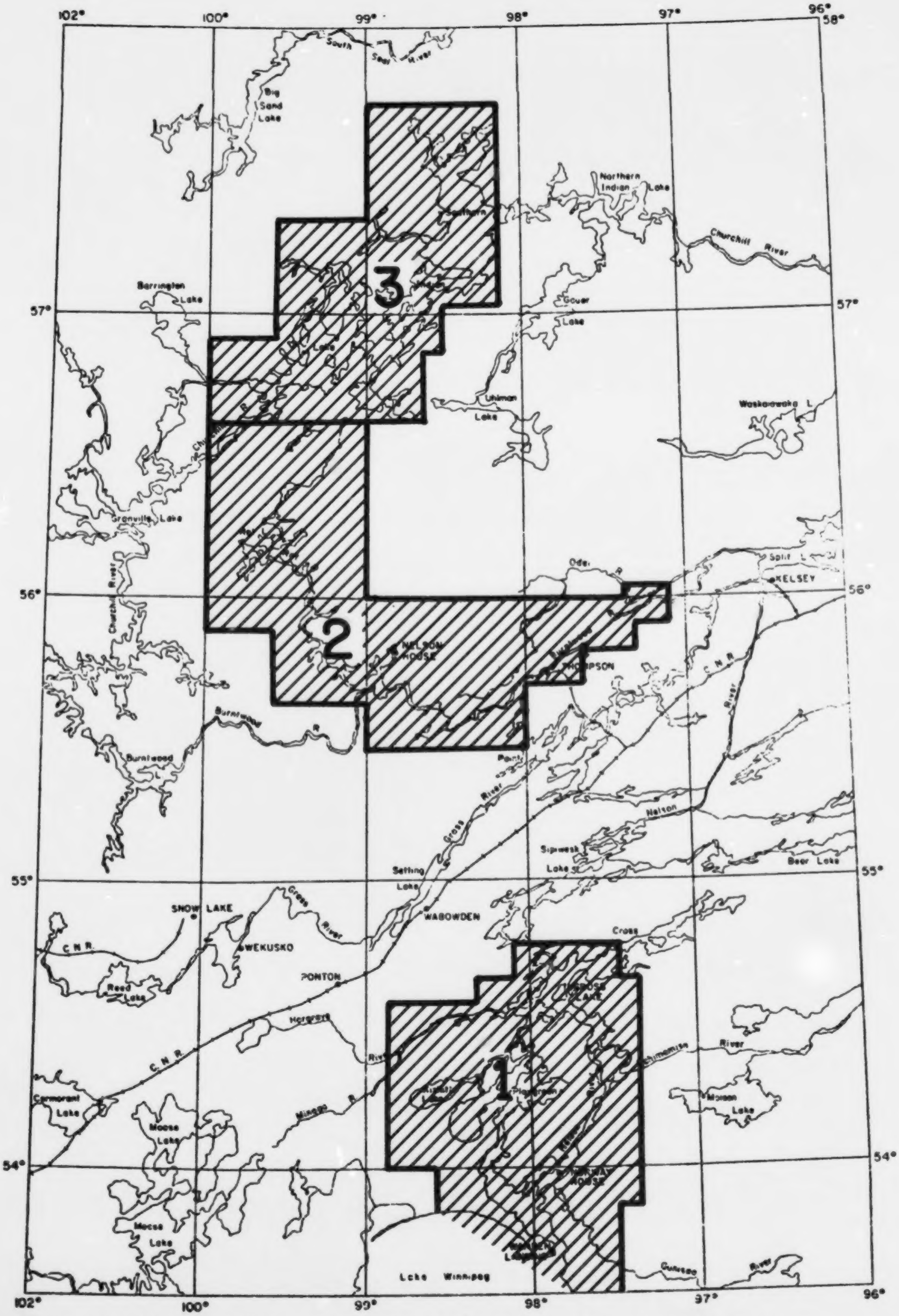
102°
100°
99°
98°
97°
96°
58°
57°
56°
55°
54°
South Seal River
Big Sand Lake
Northern Indian Lake
Churchill River
Barrington Lake
3
Gauer Lake
Uhlman Lake
Waskaiowaka L
Granville Lake
Churchill River
Odei R
Split L
KELSEY
2
NELSON HOUSE
THOMPSON
Burntwood R
Burntwood L
C.N.R.
Nelson River
Grass River
Sipiwesk Lake
Bear Lake
Setting Lake
SNOW LAKE
WABOWDEN
WEKUSKO
Cross
PONTON
Reed Lake
C.N.R.
Hargrave River
Minago R
Cormorant Lake
Moose Lake
1
Playgreen L
Echimamish River
Molson Lake
NORWAY HOUSE
Lake Winnipeg
Gunisao River
Moose Lake

Figure 1. Project Areas of the Churchill-Nelson Rivers Study Area.
Key: 1. Outlet Lakes; 2. Rat-Burntwood Rivers; 3. Southern Indian Lake.

GENERAL DESCRIPTION OF THE AREA

A. Location and Extent

The Churchill-Nelson Rivers study area extends from the northern tip of Lake Winnipeg to the northern tip of Southern Indian Lake. It is situated within the confines of the 53rd and 58th parallels and the 96th and 100th meridians.

The study are is sub-divided into three project areas identified as: Outlet Lakes, Rat-Burntwood Rivers, and Southern Indian Lake (Figure 1). The Outlet Lakes area is located immediately north of Lake Winnipeg, between latitudes [illegible] and 55° N and between longitudes 97° and 99° W. It covers an area of approximately 3,800 square miles. The Rat-Burntwood Rivers area is located between latitudes 55°30' and 56°40' N and between longitudes 96°50' and 100° W. It covers an area of approximately 5,000 square miles. The Southern Indian Lake area is situated between latitudes 56°40' and 57°45' N and between longitudes 98° and 100° W. It covers an area of approximately 4,100 square miles.

All three project areas have been mapped through interpretation of aerial photographs aided by supporting field checks. A Land System map at a scale of 1:250,000 has been prepared for each project area. Land Type maps of the to-be-flooded portions of the Outlet Lakes, Rat-Burntwood Rivers, and Southern Indian Lake project areas have been prepared at a scale of 1:50,000. The total area which has been land-typed encompasses about 1.2 million acres.

B. Transportation and Settlements

The southern half of the Churchill-Nelson study area is crossed approximately in a diagonal SW to NE manner by the Hudson Bay Railway and Provincial Road 391. A secondary road was recently completed which leads from Road 391 to the Jenpeg hydro development site. Road 391 was recently completed which leads from the City of Thompson to the town of Lynn Lake. This town is located WNW of Thompson, outside the study area.

Travel within the study area, away from the railroad line and roads, is mainly by aircraft and boat. Most air-travel is conducted by small aircraft equipped with floats which utilize the many lakes within the area as landing sites, and have their principal bases at Norway House, Thompson, and Wabowden. Facilities for land-flying aircraft are present at Norway House, Jenpeg, Thompson, Leaf Rapids, South Indian Lake, Warren Landing, Cross Lake and 8-Mile Channel. Only the landing facilities at Thompson have a hardtop surface. Scheduled air servies are available at Norway House and Thompson. Water traffic during the ice-free season is mainly by small crafts; with Norway House being serviced by a scheduled line.

The principal settlements within the area and their populations according to the 1971 Census of Canada are listed below:

Thompson	19,001
Norway House	494
Wabowden	809
Cross Lake	168
Nelson House*	1,200
Southern Indian Lake	590

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* Estimate from the Indian Affairs Branch Human Resource Survey

Thompson is located along the Burntwood River, about 400 air miles north of Winnipeg. It is a modern, new community, carved out of virgin bushland only some twelve years ago and incorporated as Manitoba's newest city on July 20, 1970. This city is on Provincial Road 391 and is connected with the Hudson Bay railway line by a spur from Sipiwesk. Thompson constitutes the centre of major mining operations at Moak Lake, Mystery Lake, Chisel Lake, Ghost Lake and Stall Lake. It is the principal centre of the study area and is emerging as the administrative and regional centre for Northern Manitoba. A number of provincial and federal offices are now located there and it is the head office site of the Norman Regional Corporation, an organization promoting the economic development of the North.

Norway House is located on the south shore of Little Playgreen Lake, about 25 miles north of Warren Landing (old site of Norway House) at the north end of Lake Winnipeg. It is the northern centre for the administration of health and welfare services, and is the site of a large, modern hospital. Also situated here are schools, two missions, stores and trading posts, a hotel, police detachment and forestry station. It is the trading centre for an Indian Reserve (population 1703).

Wabowden is a railway centre on the Hudson Bay Railway. It is located at the western edge of the surveyed section at Mile 136.5, in Township 68, Range 8 west of the Principal Meridian. This village is served by a hotel, churches, and a school. Also situated here are a Royal Canadian Mounted Police detachment, a forestry station, and a fishery.

Cross Lake is located in Township 65, Range 3 west of the Principal Meridian. It is the site of a large Catholic Mission and is the trading centre for an Indian Reserve (population 1490). There are stores, a school and a forestry station located in the village.

Nelson House is situated on the northern shore of Footprint Lake in Township 78, Range 9 west of the Principal Meridian. It is the trading centre for an Indian Reserve and has two missions, a store and a school. A branch-road from the recently-completed Thompson-Lynn Lake secondary road provides land access to this settlement.

Southern Indian Lake is located in Township 90, Range 10 west of the Principal Meridian. It has a trading post, hospital and school.

The most recent settlement to be established in the study area is the mining town of Leaf Rapids. It is situated at Leaf Rapids on the Churchill River in Township 85, Range 16 west of the Principal Meridian. It is expected to grow rapidly to become a town of several thousand inhabitants with the development of the mine at Ruttan Lake. A hotel and a fish filletting plant are situated here. Access to the settlement is provided by the recently-completed Thompson-Lynn Lake road.

C. Physiography

The term 'physiography' is taken to describe the physical features of the land according to its formative history; structure being the primary environmental control in such a classification. Constructive geological forces or prevailing structure constitutes the basis for delineating the upper levels (divisions and provinces)

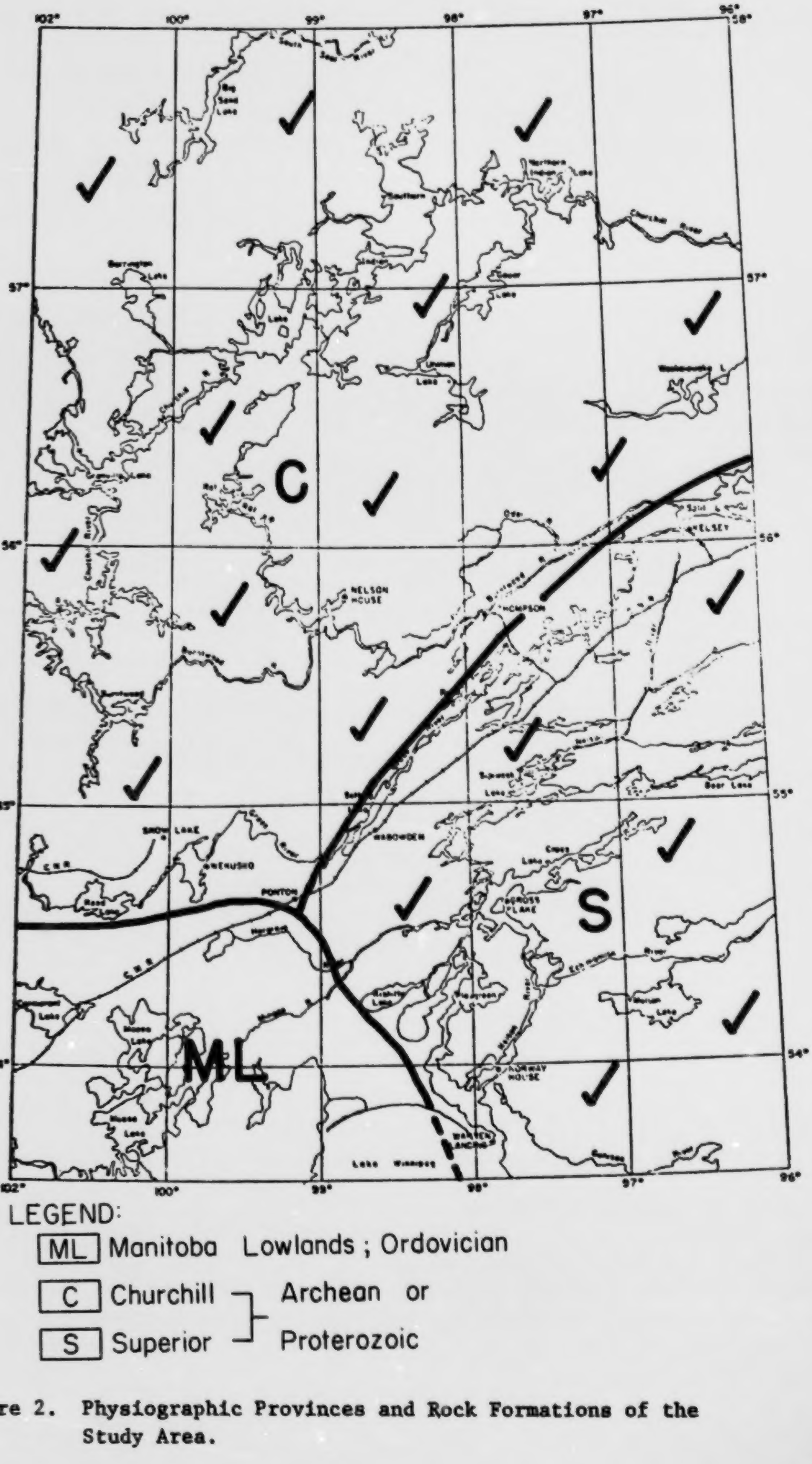
102°
100°
99°
98°
97°
96°
58°
57°
56°
55°
54°
C
S
ML
NELSON HOUSE
THOMPSON
SNOW LAKE
WABOWDEN
PONTON
CROSS LAKE
NORWAY HOUSE
WARREN LANDING
Lake Winnipeg
KELSEY
C.N.R.
LEGEND:
ML Manitoba Lowlands ; Ordovician
C Churchill
S Superior
Archean or Proterozoic

Figure 2. Physiographic Provinces and Rock Formations of the Study Area.

of the classification. The lower levels of classification are based on the destructive forces that produce the landform.

The study area is situated for the greater part in the Superior and Churchill provinces of the Canadian Shield physiographic division; a lesser portion being situated in the Manitoba Lowlands province of the Interior Plains division (Figure 2). The contact between the Canadian Shield and the Interior Plains division is located in the southwestern portion of the study area.

The Canadian Shield portion of the study area is underlain dominantly by granitic bedrock, with wide belts of gneissic and volcanic bedrock. In general, granitic bedrock is characterized by lower and more rounded slopes than gneissic bedrock; although, the slope frequency is high in both cases. The topography[1/] in the Shield portion varies from nearly level to rolling; undulating and rolling topography being most common. The topography is mainly controlled by bedrock, but a thick clay mantel often produces subdued relief. Muskegs cover most depressions and many slopes. Innumerable lakes of all sizes dot the landscape. The larger lakes are normally linked by streams interrupted by rapids and falls.

The Manitoba Lowlands portion of the study area is underlain by Ordovician dolomite or dolomitic limestone. This bedrock is aligned in flat beds that dip gently to the south. It has a nearly level to gently undulating topography. Lakes, when present, often drain through bogs.

[1/] Terminology according to that outlined in The System of Soil Classification for Canada. 1970. Canada Department of Agriculture, Ottawa.

D. Surficial Deposits

The entire area was glaciated during the Pleistocene epoch. An overall positive slope of the land in front of the glacier ensured the continued presence of a proglacial lake of varying extent, known as Glacial Lake Agassiz. In time, as the lake found lower outlets, the land surface gradually became exposed and organic materials began to accumulate in depressions.

Glacial landforms in the study area include ground moraine, end moraines, and numerous esker-kame complexes. Most of these landforms have been modified and subdued, to a greater or lesser extent, owing to their submersion in Glacial Lake Agassiz and, subsequently, to processes of erosion and organic deposition. As a consequence, these landforms, in particular the morainal ones, are often difficult to delineate or observe.

The till material of the morainal landforms in the southern half of the study area is composed mainly of highly calcareous clay. It consists of overridden lacustrine clay, owing to readvance of glacier ice across Lake Agassiz sediments, and contains relatively few stones and boulders. An exception to this occurs at the southeastern edge of the map area where the till of the "Sipiwesk" end moraine is composed mainly of boulders. A thin mantle of basal till occurs locally in the west-central portion of the study area. It has a sandy texture and is composed mainly of Precambrian materials. A calcareous clay loam till is found locally in the north and northeastern portion of the study area.

Glacio-fluvial deposits are of local occurrence, and tend to be aligned in a northeast to southwest direction. They consist of sand, gravel and cobbles of Precambrian origin mainly, and are best sorted at their southern extreme. The greater part of the esker-kame complexes have been lake-modified, as evidenced from surface sorting or the presence of a coating of lacustrine clay as well as the weakly calcareous reaction of the granular materials. Most esker-kame deposits in the southern half of the map areas also show evidence of sorting due to wave action along their eastern flank.

Unmodified Lake Agassiz sediments are the dominant deposit of the study area. These lacustrine sediments mainly have a clay texture and are highly clacareous. The surface sediments are homogeneous and sparingly stony. They are normally underlain by varved clay which may contain a few rafted stones. The varved clay usually comprises the basal unit of the lacustrine clay sequence, resting on till or bedrock, seldom on sand. The thickness of the fine-grained lacustrine deposits varies from up to 75 feet in the valleys to less than 3 feet on ridges and upper slopes. Stratified lacustrine deposits occur at higher elevations, particularly in the vicinity of glaciofluvial deposits. Beach deposits are of local significance, particularly in the southern portion of the study area. They consist of very highly clacareous silt and moderately calcareous sand.

Organic deposits occur extensively in the study area. They are the result of vegetative debris accumulating, particularly in poorly drained locations. The thickness of these deposits ranges from one foot to about 9 feet. Two broad types of organic deposits occur in the area: the mesic peats and the fibric peats. Mesic peat consists of moderately decomposed material, having an unrubbed fiber content of 33 to 66 per cent on a volume basis. Fibric peat comprises relatively undecomposed organic material, having an unrubbed fiber content greater than 66 per cent by volume. Permafrost occurs primarily in fibric peat deposits where it is encountered at about 16 inches beneath the surface.

E. Climate

The study area has a continental climate, characterized by short, cool summers and long, cold winters. In relation to worldwide climatic conditions, the area is within the Dfc[1] region; the cold-snowy forest (taiga) climates. This represents the extreme in continental climates. The climate is dominated by cold air masses during most of the winter with occasional invasions of warm air from the south. Mean annual ranges of temperature are the greatest of any climate. Precipitation is moderate to light. Summer is the season of greatest precipitation, since the extreme cold of the winter means little available moisture.

Climatic data available for the area are presented in Tables I, II, and III[2]. The mean monthly temperature shows the greatest range between the months of January and July. The greatest mean range of about 80° F occurs at Brochet; although, all other recording

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[1] W. Koppen and R. Geiger. 1936. Handbuch der Klimatologie. Bond I, Teil C. Gebruder Borntraeger, Berlin.

[2] Environment Canada, Atmospheric Environment Service. Temperature and precipitation (Prairie Provinces), 1941-1970: means and extremes.

TABLE I. MEAN MONTHLY AND ANNUAL TEMPERATURE (1941-1970).

Station	Years Recorded	Mean Monthly Temperatures (°F)												Mean Annual Temperature
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Brochet	22 yrs.	-20.3	-11.8	0.5	21.2	37.2	51.5	59.6	57.2	45.0	32.0	8.9	-9.1	22.7
Flin Flon	40 yrs.	- 7.2	0.2	13.3	32.3	46.8	58.0	64.9	61.8	49.9	38.4	17.1	0.2	31.3
Gillam	18 yrs.	-15.4	-10.0	2.4	20.4	37.0	49.9	58.9	55.9	44.1	32.3	10.5	-6.9	23.3
Norway House	Adjusted 36 yrs.	-11.7	- 4.4	7.7	29.1	43.8	56.1	63.0	60.6	49.2	37.4	14.3	-3.4	28.5
Thompson	6 yrs. *	-16.4	- 8.8	6.2	25.8	40.9	53.6	58.2	56.8	45.4	30.3	10.4	-4.7	24.0
Wabowden	27 yrs.	-11.3	- 4.4	9.6	28.0	43.1	55.1	62.3	59.1	47.8	36.4	14.3	-3.5	28.0

* Years recorded from 1967 to 1972.

TABLE II. MEAN MONTHLY MINIMUM AND MAXIMUM TEMPERATURE (1941-1970).

Station	Years Recorded	Mean Monthly Temperatures (°F)																							
		Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Yearly Average	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Brochet	22 yrs.	-24.9	-11.1	-23.1	-0.6	-12.3	13.3	9.9	32.4	27.1	47.2	41.9	61.1	51.0	68.3	49.1	65.2	38.9	51.1	26.4	37.5	1.5	16.2	- 0.8	-17.3	31.7	13.6
Flin Flon	40 yrs.	-14.7	0.3	- 8.9	9.3	2.9	23.7	22.5	42.1	36.4	57.2	48.2	67.6	55.4	74.3	52.8	70.8	42.2	57.5	31.9	45.0	11.3	22.9	- 6.4	6.8	22.8	39.9
Gillam	18 yrs.	-24.1	- 6.7	-20.8	1.3	- 9.8	14.9	9.4	31.5	26.7	47.3	37.9	61.8	46.9	70.8	44.9	66.8	35.8	52.6	25.2	39.5	4.0	17.7	-15.7	1.5	13.4	33.3
Norway House	Adjusted 36 yrs.	-22.5	- 0.8	-16.0	7.3	- 6.9	22.3	17.7	40.5	31.0	56.6	43.6	68.5	52.7	73.3	49.8	71.3	38.3	59.5	29.3	45.5	5.3	23.3	-12.8	6.1	17.5	39.5
Thompson	6 yrs. *	-25.4	- 7.3	-21.3	3.8	- 8.5	20.9	12.6	38.9	28.0	53.7	40.7	66.4	45.6	70.7	61.4	69.6	36.0	54.8	23.7	39.9	1.4	19.4	-12.6	1.8	15.1	36.0
Wabowden	27 yrs.	-19.8	- 2.9	-15.0	6.2	- 2.6	21.8	16.9	39.2	31.9	54.2	44.1	65.9	51.6	73.0	48.7	69.3	39.1	56.4	28.9	43.8	7.4	21.3	-11.3	4.4	18.3	37.7

* Years recorded from 1967 to 1972

TABLE III. MEAN MONTHLY AND ANNUAL PRECIPITATION (inc.). (1941-1970).

Station	Years Recorded	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Yearly
Brochet	22-23 yrs.	0.76	0.49	0.77	0.82	1.41	1.89	2.67	2.03	2.35	1.50	1.15	0.94	16.78
Flin Flon	17 yrs+	0.81	0.78	0.90	0.72	1.44	2.66	2.93	2.58	2.09	1.17	1.06	0.90	18.04
Gillam	18-19 yrs.	0.56	0.47	0.67	0.63	1.12	1.97	3.01	2.56	2.29	1.37	1.05	0.70	16.40
Norway House	22 yrs+	0.64	0.77	0.83	1.10	1.71	3.24	2.64	2.24	1.75	0.69	1.30	1.15	18.06
Thompson	6 yrs*	0.81	0.43	0.64	1.08	1.90	3.08	2.92	3.12	2.78	2.68	1.28	1.49	22.21
Wabowden	25-28 yrs.	0.76	0.62	0.72	0.94	1.52	2.56	2.98	2.58	2.33	1.31	1.07	0.95	18.34

* years recorded from 1967-1972.

stations have a mean range between 70 and 75°F. All recording stations have a mean annual temperature of less than 32°F, ranging from 22.7°F to 31.3°F. The mean monthly precipitation (Table III) for the stations on record is highest in the month of July. Excepting the Thompson record, the mean annual precipitation varies from 16 to 18 inches. Approximately two-thirds of the yearly precipitation falls during the summer months, between May to the end of September. On the average, less than one inch of precipitation occurs in each of the winter months. With respect to the Thompson readings, they reflect the relatively short time-period over which the recordings were made.

F. Soils

The soils of the study are are situated within two zones of the Luvisolic soil region (Figure 3). These zones are delineated on the basis of presence or absence of permafrost. Most mineral as well as organic soils in the northern-most zone contain permafrost, whereas the permafrost in the southern zone is confined mainly to the organic soils. The thickness of permafrost varies from 1 foot at the southern edge to about 75 feet at the northern edge of the map area[1,2].

Soils belonging to the Organic Soil Order [3] are well represented in the study area. The mineral soils present belong primarily to the Luvisolic, the Brunisolic, and the Gleysolic Orders. The development and nature of the major soil profiles in the study area are discussed

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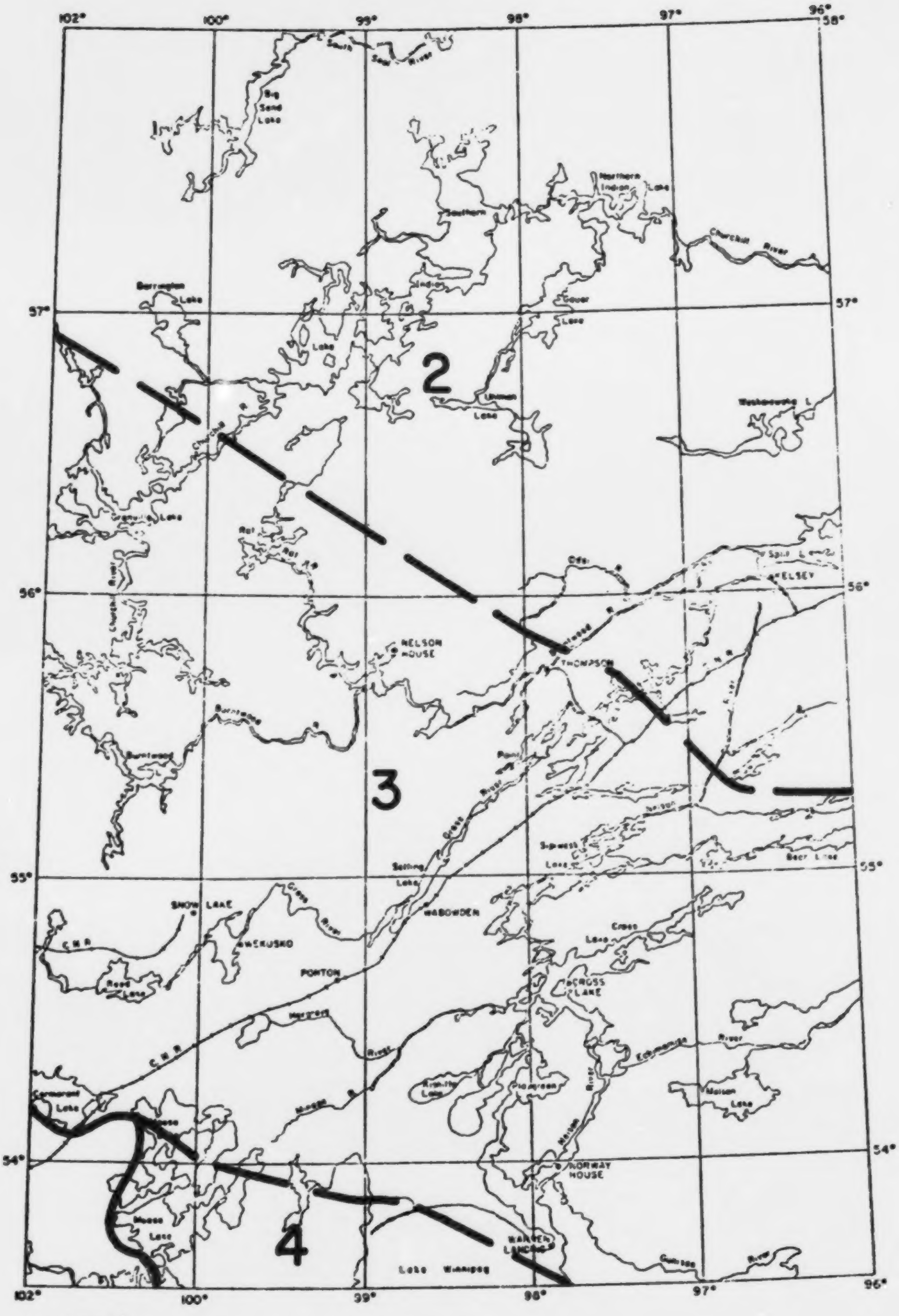
[1] Geological Survey Canada. Map 1246A. Permafrost in Canada.

[2] Brown, R.J.F. 1965. Permafrost investigations in Saskatchewan and Manitoba. Nat. Res. Coun., Div. Bldg. Res., Tech. Pap. No. 193, Ottawa.

[3] Terminology according to The System of Soil Classification for Canada. Canada Department of Agriculture, Ottawa, 1970.


102°
100°
99°
98°
97°
96°
58°
57°
56°
55°
54°
2
3
4
Big Sand Lake
Northern Indian Lake
Southern Indian
Churchill River
Barrington Lake
Uhlman Lake
Granville Lake
Rat
Rat R.
KELSEY
NELSON HOUSE
THOMPSON
Burntwood
Nelson
Sipiwesk Lake
Setting Lake
WABOWDEN
SNOW LAKE
WEKUSKO
PONTON
C.N.R.
Reed Lake
CROSS LAKE
Cross Lake
Echoing River
Molson Lake
Cormorant Lake
Playgreen
NORWAY HOUSE
WARREN LANDING
Moose Lake
Lake Winnipeg
Gunisao River

Legend:

2 Discontinuous Cryic Luvisolic Brunisolic and Widespread Cryic Organic Soil

3 Luvisolic Brunisolic and Discontinuous Cryic Organic.

4 Luvisolic Brunisolic and Localized Cryic Organic.

Figure 3. Soil Zonations for the Study Area.

TABLE IV. KEY TO SOIL SUBGROUPS[1] AND SERIES OF THE CHURCHILL-NELSON RIVER STUDY AREA

A. Soils Developed on Clay Till and Lacustrine Deposits.

1. Moderately to strongly calcareous clay till and lacustrine clay deposits.

   a) Well drained:

      Orthic Gray Luvisol - Sipiwesk series
      Solodic Gray Luvisol - Wabowden series
      Cryic* Solodic Gray Luvisol - Torrance series
      Cryic Degraded Eutric Brunisol - Notigi series

   b) Imperfectly drained:

      Gleyed Solodic Gray Luvisol - Roe Lake series
      Gleyed Cryic Solodic Gray Luvisol - Mulchay series
      Gleyed Cryic Degraded Eutric Brunisol - Barrington series
      Gleyed Cryic Orthic Regosol, Peaty phase - Orr Lake series
      Gleyed Cryic Orthic Gray Luvisol - Mynarski series

   c) Poorly drained:

      Rego Gleysol, Peaty phase - Medard series
      Cryic Rego Gleysol, Peaty phase - Partridge Breast series
      Low Humic Eluviated Gleysol, Peaty phase - La Perouse series
      Cryic Low Humic Eluviated Gleysol, Peaty phase - Muskwesi series
      Cryic Humic Eluviated Gleysol, Peaty phase - Odei series

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* These soils are affected by cryoturbation.

[1] The System of Soil Classification for Canada 1970. Canada Dept. of Agriculture. Queen's Printer.

A. 2. Moderately to very strongly calcareous stratified lacustrine silt and clay deposits[1].

a) Well drained:

Orthic Gray Luvisol - Pipun series
Cryic* Orthic Gray Luvisol - Baldock series
Orthic Eutric Brunisol - Mystery series
Cryic* Orthic Regosol - Warnews series

b) Poorly drained:

Rego Gleysol, Peaty phase - Button series

3. Moderately to very strongly calcareous stratified lacustrine silt and clay deposits underlain by bedrock.

a) Well drained:

Orthic Gray Luvisol - Drunken Lake series
Degraded Eutric Brunisol - Costello series
Cryic* Degraded Eutric Brunisol - Witchai series
Orthic Dystric Brunisol - Anson series

4. Moderately to very strongly calcareous stratified lacustrine silt and clay deposits underlain by non-calcareous, bouldery loamy sand to sandy loam till.

a) Well drained:

Orthic Gray Luvisol - Apussigamasi series

B. Soils Developed on Glacial Till

1. Non-calcareous, bouldery loamy sand to sandy loam till derived from Precambrian granitic and volcanic rock.

[1] Soils developed on stratified silt and sand (Minago Association) as described in Soil Survey Rep. No. 10 have been included in the Pipun Association for correlative purposes.

B. 1. a) Well drained:

Degraded Dystric Brunisol - Telford series

Cryic Degraded Dystric Brunisol - Lynn Lake series

2. Non-calcareous, bouldery loamy sand to sand loam till underlain by Precambrian bedrock.

a) Well drained:

Lithic Degraded Dystric Brunisol - Moss Lake series

3. Strongly calcareous, bouldery loam to clay loam till.

a) Well drained:

Cryic* Orthic Gray Luvisol - Missi Falls series

C. Soils Developed on Glacio-Fluvial Deposits

1. Non- to weakly calcareous glacio-fluvial sand and gravel.

a) Well drained to rapidly drained:

Degraded Dystric Brunisol - Clarke series

Orthic Regosol - Kame Hills series

D. Soils Developed on Organic Deposits

1. Moderately well decomposed forest peat overlying moderately to highly calcareous lacustrine clay.

a) Thin to thick (16 - 52") forest peat or thin (<24") sphagnum peat over forest peat:

Cryic Terric Mesisol - Issett series

Terric Mesisol - Cousins Lake series

Cryic Terric Humisol - Leven series

Cryic Mesisol - Nekik Lake series

Terric Fibric Mesisol - Atik series

D. 1. b) Very thick (>52") forest peat or thin (<24") sphagnum peat overlying forest peat:

Typic Mesisol - Hargrave series

Cryic Mesisol - Uhlman series

Cryic Humisol - Paimusk series

Cryic Fibrisol - Wuskwatim series

Typic Mesisol - Pemichagamau series

2. Moderately well decomposed fen peat overlying moderately to highly calcareous lacustrine clay.

a) Thin to thick (16 - 52") fen peat or thin (<24") sphagnum peat over fen peat.

Terric Mesisol - Reed Lake series

Terric Fibric Mesisol - Reed Lake complex

b) Very thick fen peat (>52") or thin (<24") sphagnum peat overlying fen peat.

Typic Mesisol - Rock Island series

3. Relatively undecomposed sphagnum peat overlying moderately to highly calcareous lacustrine clay.

a) Thin to thick (24 - 64") sphagnum peat overlying forest and/or fen peat.

Terric Mesic Fibrisol - Chocolate series

Cryic Sphagno-Fibrisol - Cormorant Lake series

Cryic Terric Sphagno-Fibrisol - Gauer Lake series

3. b) Very thick (>64") organic deposits developed from thick (24 - 51") sphagnum peat overlying forest and/or fen peat or from very thick (>51") sphagnum peat.

Mesic Fibrisol	- Kiskitto series
Sphagno-Fibrisol	- Rusty Lake series

4. Relatively undecomposed sphagnum peat overlying Precambrian bedrock.

   a) Thin to thick (24 - 64") sphagnum peat overlying forest and/or fen peat.

Cryic Sphagno-Fibrisol	- Wapisu series

briefly below. Their subgroup classification and series designation are presented in Table IV according to parent material.

Gray Luvisol soils have developed under forest vegetation on parent material that is mildly to moderately alkaline in reaction. These soils are characterized by an eluvial (Ae) horizon and illuvial, textural B horizons in which silicate clay is the main accumulation product. Under virgin conditions, the soils have organic (L-H) surface horizons. Imperfectly and well-drained soils belonging to this Soil Great Group occur predominantly on the clay till and the lacustrine deposits.

Dystric Brunisol soils have developed under forest vegetation on neutral to mildly alkaline, coarse-textured parent materials. They are characterized by organic (L-H) surface horizons, a weakly expressed eluvial (Aej) horizon and weakly expressed illuvial Bm horizons in which sesquioxides are the main accumulation product. These soils are primarily associated with the modified glacio-fluvial deposits. Some Eutric Brunisols occur within the study area. Such soils have similar profile expressions as the afore-mentioned Dystric Brunisols, but their Bm horizons consists of weak illuvial concentrations of silicate clay, if any. They have developed on mildly to moderately alkaline parent materials and, in the study area, tend to be associated with beach deposits.

Regosolic soils are well and imperfectly drained soils which lack or have very weakly expressed horizon development. In the study area they have organic (L-H) surface horizons under virgin conditions. They are of limited extent and are associated with certain extremely calcareous lacustrine deposits. In addition, recent dredge-spoil deposits would be classified as Regosolic soil.

Gleysolic soils have developed under hydrophytic vegetation and are saturated with water and under reducing conditions continuously or during some period of the year. They may have organic surface horizons (OF, OM, OH) of fibric moss or mixed peat and may have A and B horizons. As a result of the reducing conditions, their mineral matrix colours are of low chroma which may contain distinct or prominent mottles of high chroma. These soils are prominent in the study area, having developed on all the geological deposits present.

Organic soils are accumulations of organic residues which are saturated for most of the year. They consist mainly of three kinds of organic material: forest peat, Sphagnum moss peat, and herbaceous peat.

The term 'Cryic' signifies soils which are affected by cryoturbation processes. This is manifested either by a hummocky micro-relief, or the presence of permafrost, or both. This definition is more general than the one presented in The System of Soil Classification for Canada (1970), where the term 'Cryic' is restricted to soils containing permafrost within 40 inches of the mineral surface. In order to distinguish between these conditions, soils having a hummocky micro-relief with or without permafrost are differentiated from soils containing permafrost, as per C.S.S.C. (1970) definition, by an asterisk behind the term 'Cryic'.

Cryic soils having a hummocky micro-relief with or without permafrost are most readily observed in imperfectly or better drained locations. The soil hummocks have a diameter of about three feet and consist of a mound and a groove portion. The mound portion constitutes approximately 75 per cent of the hummock area and normally lacks an organic surface horizon when well drained. The groove portion of the hummock does contain an organic (L-H) surface horizon and the mineral soil material is less compacted than that of the hummock mound. The upper limit of permafrost, if any, in well drained soils is at about 6 feet from the land surface.

Cryic soils with permafrost are characterized by domed conditions, the presence of fibrous sphagnum peat or moderately decomposed forest peat and the presence of permafrost normally within two feet from the land surface. Such domes or palsas[1] may be elevated more than ten feet above the surrounding land surface. They develop when accumulating peat and living vegetation provide sufficient insulation for the frozen layer to increase in volume. As the thickness of the frozen layer, and thus the height of the palsa, increases, an unstable situation arises: the surface moss layer cracks and the sides slump. This partial destruction of the insulative cover changes the energy balance, causing the frozen layer to melt, in part or completely, with concurrent collapse of the palsa.

G. Vegetation

The study area is situated within one major vegetation belt or zone, designated as the Northern[2] or Boreal[3] Forest Region and defined by the prevalence of particular communities on approximately comparable topographical sites. This region is characterized by primarily coniferous forests with a general admixture of broad-leaved trees, such as trembling aspen, balsam poplar, and white birch. Ritchie[1] recognizes three climatically-significant vegetation zones within the study area (Figure 4); namely, the Northern Transition, the Northern Coniferous Forest, and the Mixed Forest zone. On a regional basis, these zones are presently designated, respectively, as zone 2, 3, and 4.

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[1] Zoltai, S.C. and C. Tarnocai. 1971. Properties of a wooded palsa in Northern Manitoba. Arctic-Alpine Res. 3: 115-129.

[2] Porsild, A.E. 1958. Geographical distribution of some elements in the flora of Canada. Geogr. Bull. (Can.) No. 11: 57-77.

[3] Rowe, J.S. 1959. Forest Regions of Canada. Dept. North. Affairs Nat. Resour., For. Branch Bull. 123.

The Northern Transition zone is characterized by a number of key species (Table V) and by the following conditions[2]:

1. Open black spruce forests with a ground vegetation of lichen and low prostrate shrubs and with a discontinuous stratum of medium shrubs on moist to fresh sites;
2. White spruce forests on favourable and dry sites (floodplains and eskers); jack pine forest occurring on dry sites only in the southern parts;
3. Muskeg (black spruce) and bog vegetation on saturated sites;
4. Tamarack is the most important tree of subseral communities, on moist to fresh sites, forming stands in association with willows, alder, and black spruce.

Key species of Northern Coniferous Forest zone are listed in Table VI. This zone is characterized[3] by:

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[1] Ritchie, J.C. 1962. A geobotanical survey of Northern Manitoba. Arctic Instit. North Amer., Tech. Pap. No. 9.

[2] c.f. Ritchie, J.C. 1959. The vegetation of Northern Manitoba. III. Studies in the Subarctic. Arctic Instit. North Amer., Tech. Pap. No. 3.

[3] c.f. Ritchie, J.C. 1956. The vegetation of Northern Manitoba. I. Studies in the Southern Spruce Forest zone. Can. Jour. Bot. 34: 523-561.

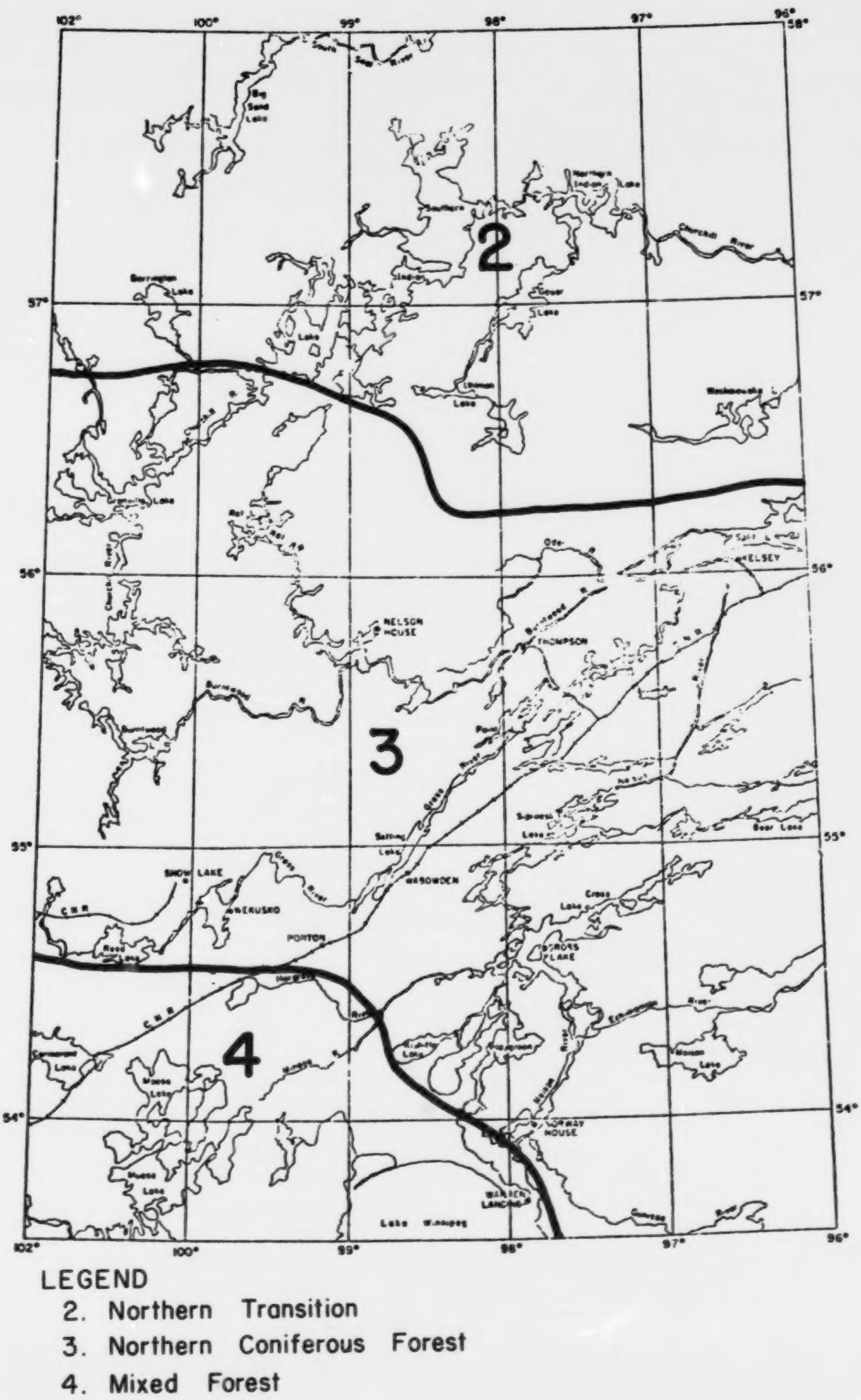
102°
100°
99°
98°
97°
96°
58°
57°
56°
55°
54°
2
3
4
Big Sand Lake
Southern Indian Lake
Northern Indian Lake
Churchill River
Barrington Lake
Granville Lake
Wuskwatim Lake
NELSON HOUSE
THOMPSON
KELSEY
Split Lake
Sipiwesk Lake
Setting Lake
WABOWDEN
SNOW LAKE
WEKUSKO
PONTON
Cross Lake
CROSS LAKE
NORWAY HOUSE
WARREN LANDING
Lake Winnipeg
Playgreen Lake
Cormorant Lake
Moose Lake
C.N.R.
LEGEND
2. Northern Transition
3. Northern Coniferous Forest
4. Mixed Forest

FIGURE 4. Vegetation zonations for the study area zone.

1. Closed black spruce forests with a continuous ground cover of mosses but lacking other tree or tall shrub stratum on moist to fresh sites;
2. White spruce occurrence is sporadic and limited to the more favourable sites;
3. Muskeg (black spruce) and bog vegetation on saturated sites;
4. Jack pine forests on dry sit4s (eskers, outcrops);
5. A seral type sequence on moist to fresh sites of birch-willow shrub —— open pine forest —— open pine forest with spruce —— mixed black spruce-white birch forest —— closed black spruce forest.

Key species of the Mixed Forest zone are listed in Table VII. This zone is characterized by:

1. Mixed white spruce-trembling aspen forests on moist to fresh sites;
2. Muskeg (black spruce, tamarack and locally eastern white cedar) and swamp and meadow vegetation on saturated sites;
3. Jack pine, aspen, or, in the southern parts, bur oak on dry sites;
4. Scrub aspen and jack pine are important trees in subseral communities.

In the study area habitat or, in the case of trees, site conditions change rapidly over relatively short distances. Nevertheless, the site is more concrete, more stable, and more readily defined than the vegetation that occupies it. Consequently, the site constitutes a better basis for the evaluation of forest communities than do the trees and other plants. Selection of one or more environmental parameters that influence vegetation and vary from one locality to the next constitute the basis of site classifications. Perhaps the most significant of these variables is the water regime; although soil permeability and nutrient regime, as well as micro-climatic conditions, cannot be discounted.

The greatest proportion of the study area is composed of sites on the wet end of the moisture scale. In some parts of this area, highly calcareous conditions may affect the growth of trees. The portion of the study area composed of the better-drained sites, is very complex, owing to rapid changes in moisture regime over relatively very short distances. Here, the proximity to bedrock and the compacted nature of the lacustrine clay material are expected to affect the growth of trees. In addition, the presence of relatively large water bodies throughout the study area should influence tree growth; although in a favourable manner. Detailed studies would be necessary to determine the magnitude of the effect of these various conditions.

The regional climate favours the growth of frost-hardy species. An analysis of climatic data by Ouellet and Sherk[1] indicates that the winter survival of ornamental trees and shrubs has a probability ranging from less than $P_e = .55$ in the northern portion to less than $P_e = .85$ near the southern limit of the study area for trees and shrubs having a hardiness class rating of 91-100. This hardiness class represents those evaluated trees and shrubs which are most winter-hardy. Even though the macro-climatic conditions in the study area are quite severe, the ability of plants to survive or thrive is highly influenced by micro-climatic variations. Such small-scale climatic variations are reflected by differences in species composition between south- and north-facing slopes as well as between proximity and distance away from large bodies of water.

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[1] Ouellet, C.E. and L.C. Sherk. 1967. Woody ornamental plant zonation III. Suitability map for the probable winter survival of ornamental trees and shrubs. Can. Jour. Plant Sci. 47: 351-358.

TABLE V. KEY SPECIES OF THE NORTHERN TRANSITION ZONE

Kind	Common Name	Scientific Name
Tree	Black spruce	Picea mariana
	White spruce	Picea glauca
	Jack pine	Pinus banksiana
	Tamarack	Larix laricina
	White birch	Betula papyrifera var. neoalaskana
Shrub	Dwarf birch	Betula glandulosa
	Willow	Salix myrtillifolia
	Willow	Salix arctica
	Baked appleberry	Rubus chamaemorus
	Crowberry	Empetrum hermaphroditum
	Rock cranberry	Vaccinium vitis-idaea
	Wild Rosemary	Andromeda polifolia
		Ledum decumbens
Grass, etc.	Tufted bog-cotton	Eriophorum angustifolia
	Cotton grass	Eriophorum spissum
	Sedge	Carex spp.
	Rush	Juncus albescens
Fern, etc.	Water-horsetail	Equisetum fluviatile linnaeanum
Moss	Sphagnum	Sphagnum fuscum
	Sphagnum	Sphagnum recurvum
	Moss	Drepanocladus spp.
	Moss	Cinclidium arcticum
Lichen	Reindeer moss	Cladonia alpestris
	Reindeer moss	Cladonia rangiferina
	Lichen	Stereocaulon paschale spp. evolutoides
	Lichen	Icmadophila ericetorum
Forb	False asphodel	Tofieldia pusilla

TABLE VI. KEY SPECIES OF THE NORTHERN CONIFEROUS ZONE

Kind	Common Name	Scientific Name
Tree	Black spruce	Picea mariana
	White spruce	Picea glauca
	Jack pine	Pinus banksiana
	White birch	Betula papyrifera
	Balsam fir	Abies balsamea
	Trembling aspen	Populus tremuloides
	Balsam poplar	Populus balsamifera
	Tamarack	Larix laricina
	White birch	Betula papyrifera var. neoalaskana
Shrub	Labrador tea	Ledum groenlandicum
	Red Osier	Cornus stolonifera
	Andromeda	Andromeda polifolia
	Leather leaf	Chamaedaphne calyculata
	Bog laurel	Kalmia polifolia
	Bramble	Rubus ideaus var. strigosus
	Baked-appleberry	Rubus chamaemorus
	Bearberry	Arctous rubra
	Rock-cranberry	Vaccinium vitis-idaea
	Sour-top blueberry	Vaccinium myrtilloides
	Mountain alder	Alnus crispa
	Willow	Salix bebbiana var. perrostrata
	Small cranberry	Vaccinium oxycoccus
Forb	Three toothed cinquefoie	Potentilla tridentata
	Wild lily of the valley	Maianthemum canadense
	Wild sarsaparilla	Aralia nudicaulus
	False Solomon's seal	Smilacina trifolia
	Buckbean	Menyanthes trifoliata
	Sweet coltsfoot	Petasites palmatus
Grass, etc.	Hairgrass	Agrostis scabra
	Blue-joint	Calamagrostis canadensis
	Sedge	Carex spp.
	Cotton-grass	Eriophorum spissum
Fern, etc.	Stiff club-moss	Lycopodium annotinum
	Wood horsetail	Equisitum sylvaticum
Moss	Schreber's moss	Pleurozium schreberi
	Moss	Hylocomium splendens
	Plum moss	Hyphnum crista-castrensis
	Sphagnum	Sphagnum warnstorfianum
	Sphagnum	Sphagnum fuscum
	Acuteleaf sphagnum	Sphagnum capillaceum
	Moss	Drepanocladus aduncus
	Moss	Tomenthypnum spp.

TABLE VI (continued)

Kind	Common Name	Scientific Name
Lichen	Reindeer moss	Cladonia alpestris
	Reindeer moss	Cladonia rangiferina
	Haircap moss	Polytrichum commune
	Lichen	Stereocaulon paschale

TABLE VII. KEY SPECIES OF THE MIXED FOREST ZONE

Kind	Common Name	Scientific Name
Tree	White spruce	Picea glauca
	Black spruce	Picea mariana
	Tamarack	Larix laricina
	Trembling aspen	Populus tremuloides
	Balsam poplar	Populus balsamifera
	Balsam fir	Abies balsamea
	White birch	Betula papyrifera
	Jack pine	Pinus banksiana
	Bur oak	Quercus macrocarpa
	American elm	Ulmus americana
	Green ash	Fraxinus pennsylvanica var. subintegerrima
	Manitoba maple	Acer negundo var. interius
	Eastern white cedar	Thuja occidentalis
Shrub	Alder	Alnus rugosa
	Black currant	Ribes americanum
	Bearberry	Arctostaphylos uva-ursi
	Blueberry	Vaccinium angustifolium
	Blue fly honeysuckle	Lonicera villosa
	Bog laurel	Kalmia polifolia
	Bog myrtle	Myrica gale
	Buch honeysuckle	Diervilla lonicera
	Common juniper	Juniperus communis
	Creeping juniper	Juniperus horizontalis
	Twin flower	Linnaea borealis
	Dewberry	Rubus pubescens
	Dwarf birch	Betula glandulosa
	Gooseberry	Ribes oxyacanthoides
	Hazel	Corylus rostrata
	High bush cranberry	Viburnum trilobum
	Labrador tea	Ledum groenlandicum
	Leather leaf	Chamaedaphne calyculata
	Pussy willow	Salix discolor
	Prickly rose	Rosa acicularis
	Red Osier	Cornus stolonifera
	Rock cranberry	Vaccinium vitis-idaea
	Sandbar willow	Salix interior
	Shrubby potentilla	Potentilla fruticosa
	Wild rosemary	Andromeda polifolia

TABLE VII (continued)

Kind	Common Name	Scientific Name
Forb	Baneberry	Actaea rubra
	Beggar ticks	Bidens frondosa
	Bishop's cap	Mitella muda
	Bluebeard lily	Clintonia borealis
	Bluewood aster	Aster cordifolius
	Bunch berry	Cornus canadensis
	Canada anemone	Anemone canadensis
	False Solomon's seal	Smilacina stellata
	Fireweed	Epilobium angustifolium
	Marsh five finger	Potentilla palustris
	Marsh marigold	Caltha palustris
	Pink wintergreen	Pyrola asarifolia
	Pitcher plant	Sarracenia purpurea
	Sundew	Drosera rotundifolia
	Tall meadow rue	Thalictrum dasycarpum
	Cow parsnip	Heracleum lanatum
	Water Plantain	Alisma triviale
	Wild columbine	Aquilegia canadense
	Wild lily of the valley	Maianthemum canadense
	Wild mint	Mentha arvensis
	Wild sarsaparilla	Aralia nudicaulis
Grass, etc.	Arrow grass	Triglochin maritima
	Baltic rush	Juncus balicus
	Blue joint	Calamagrostis canadensis
	Cattail	Typha latifolia
	Common bulrush	Scirpus validus
	Cotton grass	Eriophorum angustifolium
	Spike rush	Eleocharis acicularis
	Wild rice	Zizania aquatica
Fern, etc.	Club moss	Lycopodium clavatum
	Spike moss	Selaginella rupestris
	Horse tail	Equisitum sylvaticum
	Bracken	Pteridium aquilinum
Moss	Broom moss	Dicranum scoparium
	Hair-cap moss	Polytrichum commune
	Nodding pohlia	Pohlia nutans
	Ribbed bog moss	Aulacomnium palustre
	Schreber's moss	Pleurozium schreberi

METHODS

A. The Land Classification System

The bio-physical system of land classification was selected for this study. The hierarchy of this system was outlined by Lacate (1969)[1] and adapted to Manitoba conditions by Zoltai, Oswald, and Tarnocai (1969)[2]. In the course of this study, the system has been further modified with respect to the coding system and the cartographic presentation.

Land Regions (Level 1)

Land Regions are defined as areas of land characterized by a distinctive regional climate as expressed by vegetation (Lacate, 1969). The Land Region is usually of large areal extent and is inevitably more or less heterogeneous. It is often an aggregation of several distinctive contiguous landscapes.

Land Districts (Level 2)

Land Districts are defined as areas of land within Land Regions characterized by a distinctive pattern of relief, geology, geomorphology, and associated vegetation (Lacate, 1969). Land Districts are distinguished primarily on the basis of major physiographic and/or geologic patterns which characterize the landscape as a whole.

Land System (Level 3)

A Land System is defined as an area of land throughout which there is a recurring pattern of landform, soils, and vegetation

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[1] Lacate, D.S. 1969. Guidelines for bio-physical land classification (Progress Report). Can. Dept. For. and Rural Dev., 46 pp.

[2] Zoltai, S.C., E.T. Oswald, and C. Tarnocai. 1969. Land classification for land evaluation: Cormorant Lake Pilot Project. Can. Dept. For. and Rural Dev., Inf. Rep. MS-X-20, 31 pp.

(Lacate, 1969).

Land Type (Level 4)

A land type is defined as an area of land on a particular landform segment, having a fairly homogeneous combination of soil and chronosequence of vegetation (Lacate, 1969). Land Types are grouped into Land Systems where they recur in a recognizable pattern.

In this study, Land Types have been presented mainly in terms of complexes, owing to the complexity of the terrain and limited time for completion of the study.

Landscape Unit

The Landscape Unit was introduced as a land classification level by Zoltai, Oswald, and Tarnocai (1969), and considered as a level of the classification system for the Outlet Lakes project area of the Churchill-Nelson Rivers study area. It was an attempt to integrate the land and water portion of the landscape.

Landscape Units are defined by their land or water characteristics, or a combination of these. They are comprised of patterns of land types and water types grouped together to provide a convenient unit for resource management and multiple land use planning. Thus, landscape units are broad patterns of land and water, grouped into areas, using physiographic criteria.

The legend format has undergone considerable change from that advised by Lacate (1969). The Land Regions are identified by numerical codes corresponding to those used in climatic zonation. Land District codes are alphabetic, representing the initials of their names. Landscape

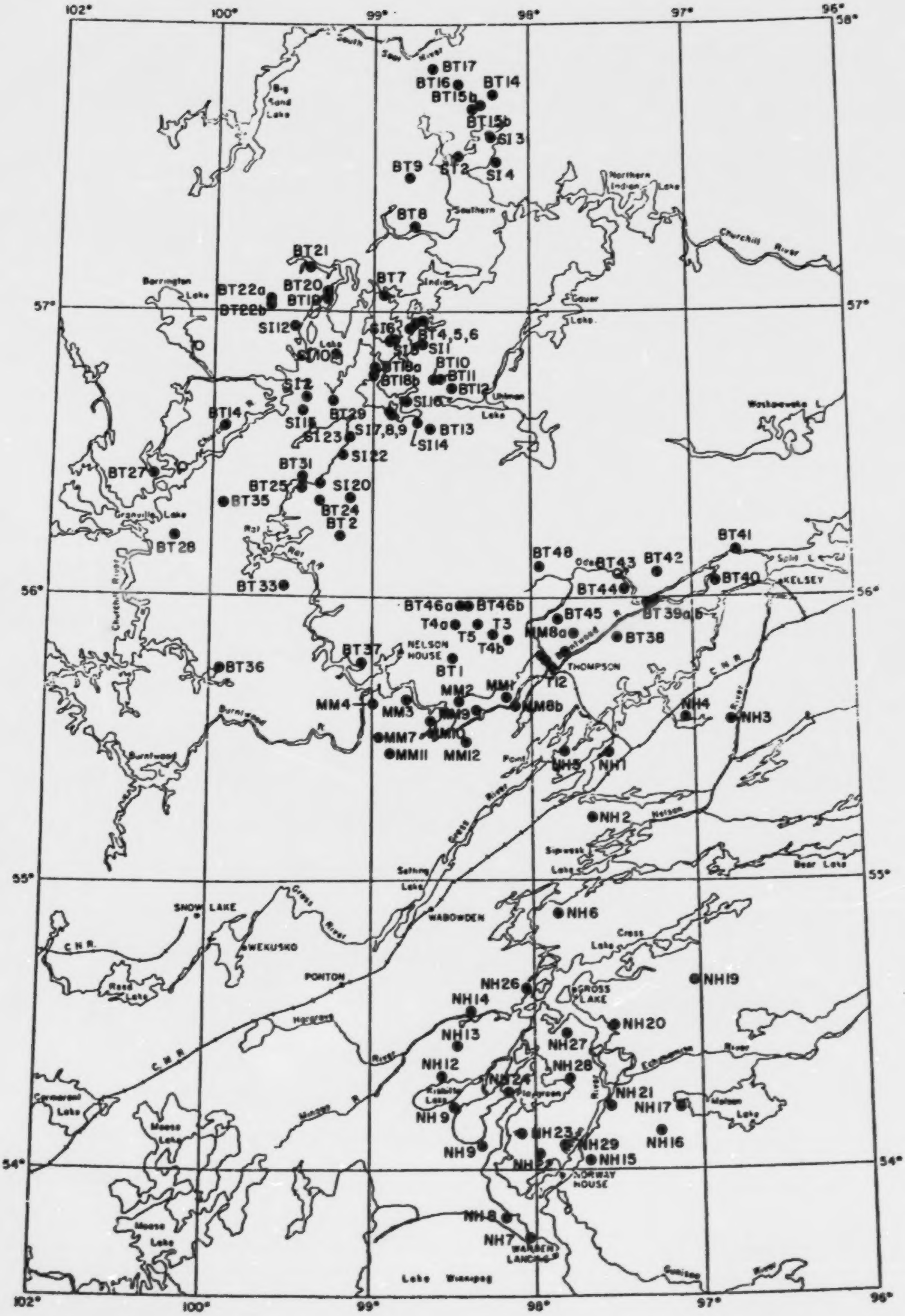
Units are coded as consecutive numerals. The codes for Land Systems have been restricted to the identification of geological materials and relief classes.

In the Land System code, the letter "P" has been replaced by "B, T, S, or F" to facilitate the identification of the various organic landforms and associated materials. Dominance of these materials is indicated when placed before the numeral, whereas it signifies sub-dominance when following the numeral, even though it occupies large areas. A lower case letter following the numeral indicates the petrography of the dominant mineral soil or the presence of permafrost. Lower case letter codes for permafrost may also be associated with the capital letter codes of organic materials. A code placed between brackets indicates the occurrence of minor amounts (less than 15 per cent) of materials important to management practices.

B. Sampling

Vegetation samples were taken at most sites (Figure 5) for identification and cross-examination purposes. The specimens were placed in plastic bags at the time of sampling and transferred to a plant press upon arrival at base-camp.

A number of soil samples, representative of site conditions and soil pattern, were sampled in each of the project areas (Figure 6) for chemical and physical characterization. The soils were sampled according to horizon sequence within the soil pedon. In addition to these horizon samples, soil ped samples were taken for bulk density and dispersibility from horizons showing good structure. These soil



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South Seal River
Big Sand Lake
Northern Indian Lake
Southern Indian Lake
Churchill River
Barrington Lake
Gauer Lake
Uhlman Lake
Waskaiowaka L.
Granville Lake
Rat L.
Churchill River
Burntwood R.
Split L.
KELSEY
NELSON HOUSE
THOMPSON
C.N.R.
Nelson River
Sipiwesk Lake
Bear Lake
Setting Lake
Grass River
WABOWDEN
SNOW LAKE
WEKUSKO
PONTON
Reed Lake
Cross Lake
CROSS LAKE
Echoing River
Minago R.
Kiskitto Lake
Playgreen
Molson Lake
Cormorant Lake
Moose Lake
NORWAY HOUSE
WARREN LANDING
Lake Winnipeg
Gunisao River
BT17
BT16
BT14
BT15b
BT15b
SI3
BT9
SI2
SI4
BT8
BT21
BT7
BT20
BT22a
BT19
BT22b
SI12
SI6
BT4,5,6
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SI1
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BT18a
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BT11
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BT46b
BT39a,b
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T5
T4b
MM8a
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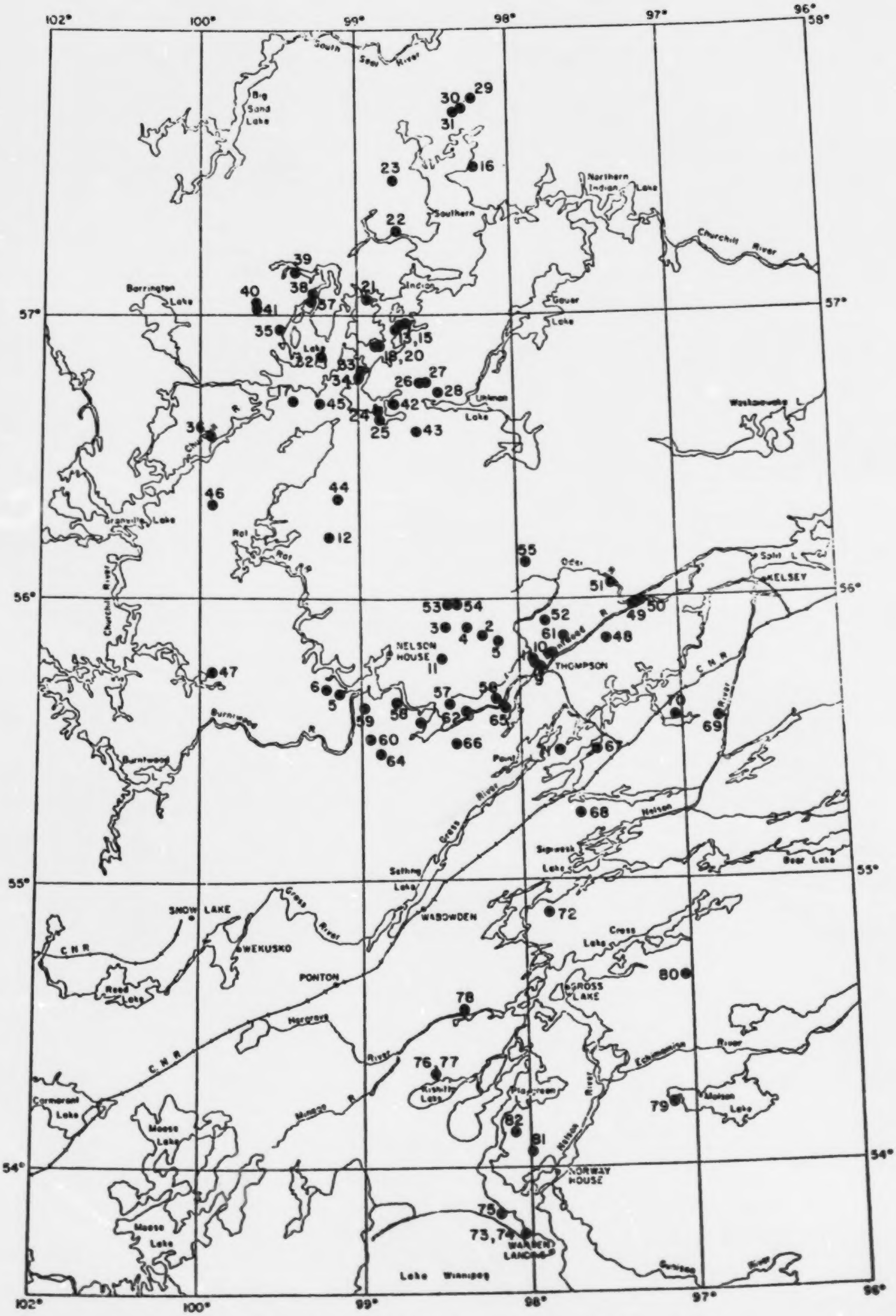
Figure 5. Location and designation of sites in the study area.


102°
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South Seal River
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Grass River
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Hargrave River
Minago R.
Kiskitto Lake
Playgreen
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Echimamish River
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Cormorant Lake
Moose Lake
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Lake Winnipeg
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Figure 6. Location and identification number of the soils sampled in the study area.

ped samples were wrapped in plastic wrap and transported in styrene cups to prevent breakage.

All mineral soil samples were air-dried upon arrival at the laboratory while the organic samples were placed in cold storage. The mineral horizon samples were then oven-dried at 60°C for at least 12 hours. They were subsequently crushed in a steel-roller mill to pass a 2 mm sieve and stored in cardboard containers. The material greater than 2 mm was weighed and their content and mean size diameter recorded.

C. Analytical Methods

The analytical methods listed are as described by Beke[1], unless otherwise stated.

1. Physical Analyses

Mechanical analysis: This determination was made according to the pipette method. Salts were removed from the soil by repeated washings, if necessary, and organic matter by addition of H_2O_2. Carbonates were not removed. The sand fraction was further fractionated whenever the sand content of the sample was greater than 10 per cent.

Bulk density: Bulk density measurements were obtained according to the ped-coating method.

Erodibility: The suspension percentage and dispersion ratio were determined from measurement of the water dispersibility of soil aggregates.

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[1] Beke, G.J. 1972. Laboratory methods of the Manitoba Soil Survey. Can. Dept. Agric., Res. Stn., Pedology Unit, Internal Rep.

Plasticity: The plastic and liquid limits were determined according to the method of the American Society for Testing Materials, as recorded by Beke (1972)[1].

Shrinkage: Shrinkage factors of soils were determined according to the method of the American Society for Testing Materials, as recorded by Beke (1972)[2].

2. Chemical Analyses

pH: Soil reaction was determined on a 1:1 soil to solution ratio using a Radiometer pH meter equipped with a glass and a calomel electrode. The pH of mineral samples was determined with $CaCl_2$, while KCl was used for organic samples.

Conductivity: The electrical conductivity of the soil solution was determined on saturation extracts using a pipette-type conductivity cell and a conductivity bridge.

$CaCO_3$ equivalent and Calcite and Dolomite content were determined by a manometric method. The samples were ground to pass a 32-mesh sieve prior to analysis.

Organic carbon: A modification of the sulphuric acid heat-of-dilution method was used for the determination of organic carbon. The samples were ground to pass a 60-mesh sieve prior to analysis.

Total nitrogen: A modification of the Kjeldahl method was used for the determination of total nitrogen. The catalyst used was a commercial product known as Kelpak No. 2. A boric acid solution was used to collect the distilled ammonia. The ammonium-N content was determined using standardized H_2SO_4.

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[1] Beke, G.J. 1972. Laboratory methods of the Manitoba Soil Survey. Can. Dept. Agric., Res. Stn., Pedology Unit, Internal Rep.

[2] ibid.

Exchangeable cations and exchange capacity: Exchangeable cations were extracted from the mineral soil samples with 1N ammonium acetate adjusted to pH 7.0. Exchangeable potassium and sodium were determined with a Perkin-Elmer model 303 Atomic Absorption Spectrophotometer. Calcium and magnesium were determined titrimetrically using standardized E.D.T.A. The cation exchange capacity was determined by extraction of adsorbed ammonia with 1N NaCl and subsequent distillation of the extract.

The cation exchange capacity of organic samples was determined by extraction of adsorbed chlorine with barium acetate followed by titration of the extract. Exchangeable cations were extracted from the organic sample with 1N ammonium acetate and determined in a similar manner as for mineral soils.

Exchange acidity was determined by leaching the soil with barium acetate followed by titration of the leachate with standardized sodium hydroxide.

$NaHCO_3$-soluble phosphorus: Soil phosphorus was extracted with sodium bicarbonate and determined colorimetrically using acid molybdate (Jackson, M.L., 1958. Soil Chemical Analysis. Prentice-Hall, Inc., Englewood Cliffs, N.J., U.S.A.).

Fiber analyses: Both the unrubbed and rubbed fiber contents were determined on a volume basis. The volume of pre-treated organic material retained after washing in a 100 mesh sieve was measured in a half-syringe and reported to the nearest per cent.

Pyrophosphate: The sodium pyrophosphate solubility of organic material was determined by measuring the absorbance of the extract on a spectrophotometer.

Ash: The organic material was ashed at a low temperature (400°C) and weighed.

BIO-PHYSICAL RELATIONSHIPS

A. Land Regions, Districts, and Landscape Units

The Land Regions, Land Districts and Landscape Units recognized in the study area are presented in Table VIII. Approximate locations of the Land Regions and Land Districts are illustrated in Figure 7. The general characteristics of these Bio-physical Land Classification levels are described below. Detailed descriptions of the Land Districts delineated in the Southern Indian Lake and Rat-Burntwood Rivers project areas and of the Landscape Units recognized in the Outlet Lakes project area are presented in Annex I.

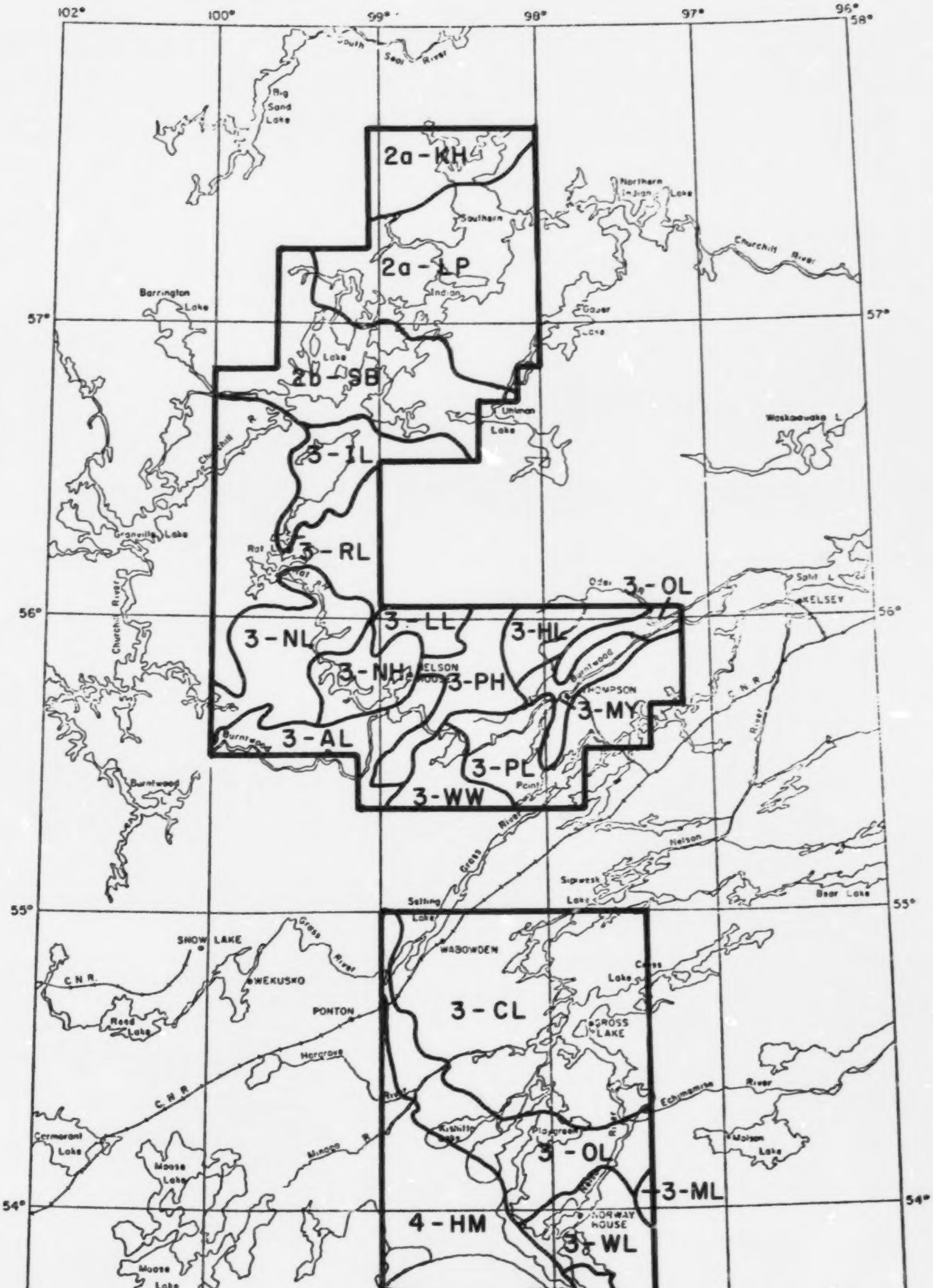
1. Land Regions

Boreal-Arctic Land Region (2): Regional vegetation on gently sloping, medium and fine textured materials, is open black spruce forest with a ground cover of lichen and low prostrate shrubs. White spruce occurs on flood plains, sand plains and bedrock outcrops; jack pine occurring on the dry sites only in the southern parts. Discontinuous permafrost occurs throughout the Region; common occurrence of wood mineral and peat palsas as well as mineral soil hummocks. Land sub-Region 2a represents the typic condition of this Land Region while sub-Region 2b is transitional to the Boreal Land Region.

Boreal Land Region (3): Regional vegetation on gently sloping, medium and fine textured materials is closed black spruce forest with a continuous ground cover of mosses. White spruce and trembling aspen are restricted to lake shores and river courses. Jack pine occupies sand plains and bedrock outcrops. Localized permafrost in mineral materials;

TABLE VIII. LAND REGIONS, DISTRICTS AND LANDSCAPE UNITS IN THE STUDY AREA

LAND REGION	LAND DISTRICT	LANDSCAPE UNITS (#)	PROJECT AREA
2. Boreal-Arctic	K.H. Kame Hills		Southern Indian Lake
	L.P. Long Point		
	S.B. South Bay		
3. Boreal	I.L. Issett Lake		Rat-Burntwood Rivers
	R.L. Rat Lake		
	N.L. Notigi Lake		
	N.H. Nelson House		
	W.W. Wuskwatin Lake		
	L.L. Leftrook Lake		
	A.L. Apeganau Lake		
	P.H. Partridge Crop Hill		
	H.L. Hunter Lake		
	P.L. Paint Lake		
	M.Y. Mystery Lake		
	M.L. Molson Lake	18	Outlet Lakes
	W.L. Wabisi Lake	08, 13, 14, 15, 16	
	C.L. Cross Lake	25, 26, 27, 28, 29, 30, 31 32, 33, 34, 35, 36	
	O.L. Outlet Lakes	05, 06, 07, 09, 17, 19, 20, 21, 22, 23, 24	
4. Mixed Boreal	H.M. Hargrave	01, 02, 03, 04	
	M.P. Montreal Point	10, 11, 12	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South Seal River
Big Sand Lake
2a - KH
Northern Indian Lake
Southern
2a - LP
Indian
Churchill River
Barrington Lake
Gauer Lake
2b - SB
Lake
Uhlman Lake
Waskaiowaka L
3 - IL
Churchill R.
Granville Lake
3 - RL
Rat
Odei
3 - OL
Split L
KELSEY
3 - NL
3 - LL
3 - HL
3 - NH
NELSON HOUSE
3 - PH
Burntwood
THOMPSON
3 - MY
C.N.R.
River
3 - AL
Burntwood
3 - PL
Paint
3 - WW
Churchill River
Burntwood L
Grass River
Nelson
Sipiwesk Lake
Bear Lake
Setting Lake
SNOW LAKE
Grass River
WABOWDEN
C.N.R.
WEKUSKO
Cross Lake
PONTON
3 - CL
CROSS LAKE
Reed Lake
Hargrave
C.N.R.
River
Echimamish River
Cormorant Lake
Kiskitto Lake
Playgreen L
Molson Lake
Minago R.
3 - OL
Moose Lake
3 - ML
NORWAY HOUSE
4 - HM
3 - WL
Moose Lake
WARREN LANDING
4 - MP
Gunisao River
Lake Winnipeg

Figure 7. Land Regions and Land Districts of the Study Area.

but discontinuous occurrence of wooded palsas and peat plateaux with permafrost in organic materials.

Mixed Boreal Land Region (4): Regional vegetation on gently sloping medium and fine textured materials is mixed white spruce-trembling aspen forests. Jack pine, aspen, or, in the southern parts, bur oak occur on sand plains and bedrock outcrops. Localized permafrost in organic materials in the northern portion of this Land Region.

2. Land Districts

Kame Hills Land District (KH): Characterized by low relief peat plains interspersed with moderate relief trains of modified glaciofluvial deposits. Moderately to strongly calcareous glacial till deposits outcrop in the northeastern portion of the District. Lacustrine deposits occur beneath the peat accumulations. Permafrost occurs discontinuously throughout the area.

Long Point Land District (LP): Characterized by gently undulating to rolling topography, controlled by Precambrian gneissic and granitic bedrock. The area is covered by lacustrine deposits, underlain in places by morainal till, and contains numerous bedrock outcrops. Peat plains occur in the depressions. Most materials contain permafrost, which is discontinuous in distribution.

South Bay Land District (SB): An area of moderate relief, comprising low relief, peat-covered valleys and low relief, bedrock-controlled uplands. Lacustrine deposits underlay the peat plains and also cover the bedrock uplands, in part. Permafrost occurs discontinuously in all materials, excepting esker-kame deposits.

Issett Lake Land District (IL): Characterized by low relief lacustrine and peat plains interspersed with Precambrian bedrock outcrops. The organic deposits are thick and are underlain by lacustrine materials. Permafrost is of local occurrence in the mineral deposits and occurs discontinuously in the organic materials.

Rat Lake Land District (RL): An area of moderate relief comprising low relief, bedrock-controlled uplands and low relief valleys. The valleys contain deep lacustrine deposits which may be covered by thin to thick organic accumulations. Permafrost is of local extent in the mineral deposits; but is discontinuous in thin to thick organic materials.

Notigi Lake Land District (NL): Characterized by gently to strongly rolling topography, controlled by frequently exposed Precambrian gneissic or granitic bedrock. Lacustrine deposits, with or without organic-material overlays, occur in valleys and depressions. Peat accumulations frequently contain permafrost, which is of local extent in the mineral materials.

Nelson House Land District (NH): Characterized by gently undulating to rolling topography, controlled by Precambrian bedrock. The area is covered by lacustrine materials but contains numerous bedrock outcrops. Peat plains occur in the depressions. Permafrost occurs frequently in peat accumulation; being of local extent in mineral deposits.

Wuskwatin Lake Land District (WW): Characterized by low relief plains of peat and lacustrine deposits, controlled slightly by Precambrian bedrock. Bedrock outcrops occur infrequently. Lacustrine clay and silt occur beneath the peat accumulations. Permafrost occurs extensively in peat deposits and locally in mineral materials.

Leftrook Lake Land District (LL): Characterized by low relief plains of stratified lacustrine and peat deposits interspersed with bedrock-controlled uplands. Lacustrine materials occur beneath the peat accumulations. Permafrost occurs in mineral materials but is more extensive in organic accumulations.

Apeganan Lake Land District (AL): Characterized by low relief plains of lacustrine and peat deposits. Bedrock is exposed or close to the land surface in isolated portions of this Land District. Lacustrine materials occur beneath the peat accumulations. Permafrost occurs extensively in the peat accumulations and, to a lesser extent, in the mineral deposits.

Partridge Crop Hill Land District (PH): Characterized by very gently undulating to rolling topography of sandy end-morainic and glaciofluvial deposits, lacustrine deposits, organic accumulations, and bedrock outcrops. The topography of the lacustrine deposits is largely bedrock-controlled. Peat deposits are underlain by lacustrine materials. Permafrost occurs discontinuously in the peat accumulations.

Hunter Lake Land District (HL): Characterized by low relief lacustrine and peat plains with isolated Precambrian granitic and gneissic bedrock outcrops. Lacustrine materials occur beneath the peat deposits. Permafrost occurs discontinuously in the peat accumulations and locally in the mineral materials.

Paint Lake Land District (PL): Characterized by low relief plains of lacustrine and peat deposits with infrequent bedrock outcrops. The lacustrine deposits are thick and have a very gently undulating to gently rolling topography. Peat deposits are underlain by lacustrine materials. Permafrost occurs locally in mineral materials and discontinuously in peat accumulations.

Mystery Lake Land District (MY): An area of moderate relief, characterized by gently undulating to gently rolling lacustrine deposits and undulating to rolling glacio-fluvial materials. Precambrian bedrock outcrops occur infrequently. Organic accumulations of varying thickness overlay the lacustrine deposits. Permafrost occurs discontinuously in the peat accumulations and less extensively in the mineral deposits.

Molson Lake Land District (ML): Characterized by rolling topography, controlled by Precambrian bedrock. The area is covered by discontinuous lacustrine clay and some cobbly morainal till. Bedrock outcrops are numerous. Peat Plains occur in the depression. Permafrost occurs locally to discontinuously in the organic accumulations.

Wabisi Lake Land District (WL): Characterized by undulating to rolling topography, controlled by peat plains and Precambrian granitic bedrock outcrops with isolated occurrences of modified, glacio-fluvial deposits. The peat plains are generally underlain by lacustrine clay. Permafrost is of local to discontinuous occurrence in the peat accumulations.

Outlet Lakes Land District (OL): Characterized by low relief peat plains with isolated Precambrian granitic bedrock outcrops and trains of modified glacio-fluvial deposits. Lacustrine clays occur beneath the peat accumulations. Permafrost occurs discontinuously locally in the peat accumulations and locally in mineral deposits.

Cross Lake Land District (CL): Characterized by undulating to gently rolling topography, controlled by Precambrian gneissic or granitic bedrock. The area is covered by lacustrine clay, underlain in places by fine-textured morainal till, and contains numerous bedrock outcrops. Peat plains occur in the depressions. Permafrost occurs discontinuously locally in the peat accumulations and locally in mineral deposits.

Hargrave Land District (HL): Characterized by low relief peat plains with few, low relief, lacustrine and modified glacio-fluvial outcrops. A nearly continuous layer of lacustrine clay occurs underneath the peat material. In a large proportion of the area, the lacustrine clay is underlain, in turn, by fine-textured morainal till. Permafrost is of local extent in peat accumulations.

Montreal Point Land District (MP): Characterized by low relief peat plains with isolated Precambrian granitic rock outcrops. A nearly continuous layer of lacustrine clay is present beneath the peat material, overlying fine-textured morainal till in part of the area. Permafrost occurs locally in peat accumulations.

B. Description of Ecosystems

This section describes and illustrates the attributes of the principal ecosystems occurring in the study area. In instances, the delineated ecosystems cover a range of conditions and, hence, would constitute ecosystem complexes. The attributes are discussed under the headings: physiographic position and landform, soil characteristics, and biotic characteristics. In addition, an evaluation is provided of the sensitivity of each ecosystem to environmental disturbance.

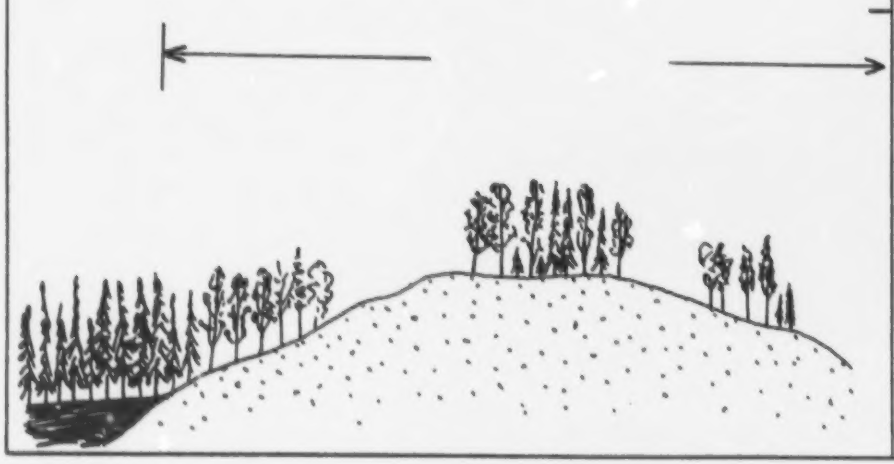
ECOSYSTEM GLACIO-FLUVIAL SAND, DRY

ECOREGION 2 a BLACK SPRUCE, JACKPINE - LICHEN

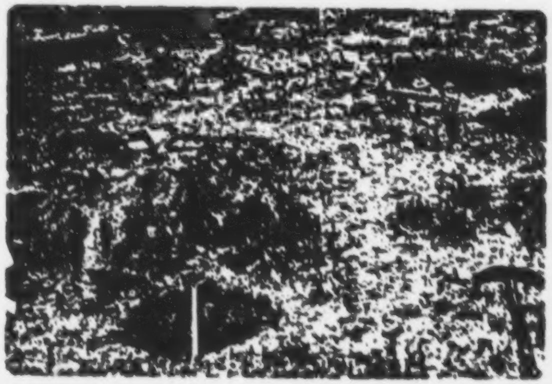
MAPPING s1

SYMBOL d

PHYSIOGRAPHIC POSITION AND LANDFORM



SOIL CHARACTERISTICS



Orthic Regosols and Degraded Dystric Brunisols developed on sand textured, lake modified glacio-fluvial and beach deposits. The Orthic Regosols occur in the blowout areas of esker-kames as well as recently formed beaches (c.f. BT 6). The degraded Dystric Brunisols are characterized by a distinct, light gray, strongly acid Ae horizon and a friable, yellowish-brown Bm horizon having a weak concentration of iron, aluminum, and organic matter (c.f. sites BT4 and 9).

BIOTIC CHARACTERISTICS

MAPPING S1
SYMBOL d

FOREST COVER

Varies considerably as result of fire history, wind erosion, exposure etc. Stands of Jack pine, Black spruce and occasionally White spruce can be found. They vary from very open, with lichen covered wind eroded soil surfaces, to semi-open stands (Jack pine, Black spruce). White birch may occur sporadically.

UNDERSTORY AND GROUNDCOVER

On top of ridges: Arctostaphylos uva-ursi, Empetrum hermaphroditum, Cladonia spp., Vaccinium vitis-idaea, V. myrtilloides, V. uligonosum. Bare, windblowm areas are very common. Lichen and organic debris occur in variable quantities. Slopes of the landform are often steep and, depending on exposure have a varied kind of vegetation; e.g. Polytrichum commune, Ledum groenlandicum, Geocaulon lividum, Alnus crispa and a variety of Lichen spp.

SUCCESSION

As result of fire Jack pine forms in many cases, pure or mixed stands on these sites. When undisturbed for long periods Black spruce will form the forest cover.

SENSITIVITY

The material of these landforms is very well suited for road building and other construction purposes because of its granular texture and rapid internal drainage. Ecosystems like these are not too sensitive to erosion and flooding. Trees will easily be uprooted and good sandy beaches will form provided the slope below the water level is not too steep. Formation of stable shorelines will not take too long a time.

Mixture of Jack pine and Black spruce. Note the barren sandy exposures.

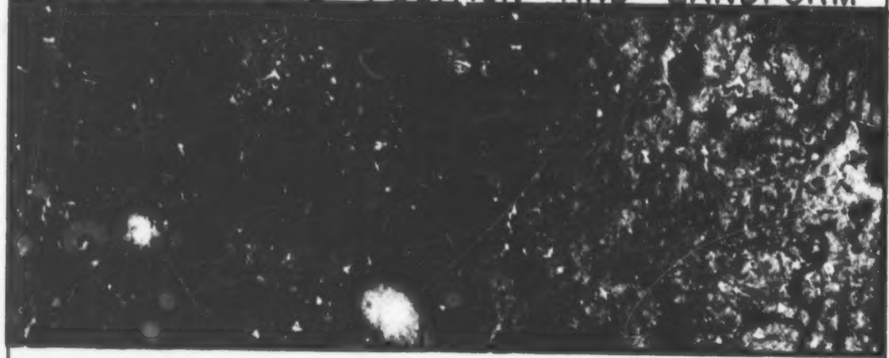
Jack pine stand being invaded by Black spruce.

ECOSYSTEM SHALLOW ORGANIC OVER LACUSTRINE, MOIST, PERMAFROST

ECOREGION 2 a BLACK SPRUCE-SPHAGNUM-FEATHERMOSS

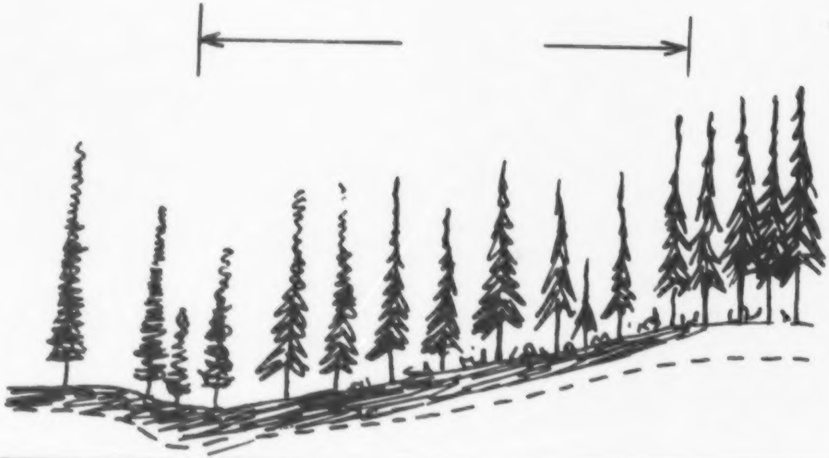
MAPPING SYMBOL $\frac{OF}{Ch}$, $\frac{OM}{Ch}$ m - w

PHYSIOGRAPHIC POSITION AND LANDFORM



PERMAFROST

Depth of active layer from 3½-2 feet. Shallower under sphagnum hummocks. A large amount of ice crystals in peat and underlying mineral soil. Ice lenses very common, especially in clay.



SOIL CHARACTERISTICS

Cryic Humic Eluviated Gleysols characterized by a 6 to 24 inches thick O horizon and underlain by a dark colored granular Aehg and dull colored Btg horizons. Permafrost (z) occurs within 40 inches of the mineral surface. These soils are moderately fine textured, having developed on moderately to very strongly calcareous lacustrine deposits. Sites BT7, 8, 17 and 48 are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL $\frac{OF}{Ch}$, $\frac{OM}{Ch}$

FOREST COVER

Composed of very open Black spruce. Stands are not merchantable, even at maturity, which may be reached after 120-170 years. Basal area per acre may be about 40-20 square feet. Heights of trees vary from 5-25 feet. Stands can be considered a class 7 according to C.L.I. rating.

UNDERSTORY AND GROUNDCOVER

Occasional willow and alder, up to 5 feet tall, may occur but more common is Betula glandulosa, and occasionally Chamaedaphne calyulata. Some bS-regeneration in the form of seedlings or as result of layering are found. Other species found are: Ledum groenlandicum, Vaccinium vitis-idaea, V. uligonosum, V. oxycoccos, Empetrum hermaphroditum, Rubus chamaemorus, Kalmia polifolia, Petasites palmatus, Sphagnum fuscum, S. decumbens, S. rubrum, Cladonia alpestris, C. rangiferina, Dicranum fuscum, D. scorparium, D. rugosum, Polytrichum commune, Pleurozium schreberi and Peltigera aphthosa. Ledum decumbens may be found on some sites in the most northern part of the region.

SUCCESSION

After a fire the forest stand usually regenerates back to Black spruce. Also the sphagnum is not alway completely burned. A large proportion of Willow and some ericaceous shrubs may appear.

SENSITIVITY

Highly sensitive to flooding, erosion and construction. Flooding and construction will likely cause the melting of the permafrost, which may result in collapsing and slumping.
New stable shorelines will take a long time to develop.

Open uneven aged Black spruce. Note the tamarack in the foregound.

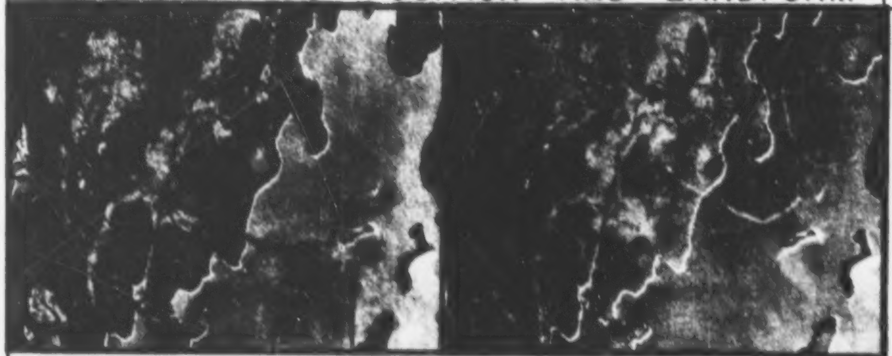
Shoreline in organic over clay. These shorelines are not stable and erode continuously. Some leaning trees can be noted.

ECOSYSTEM LACUSTRINE AND CALCAREOUS TILL, FRESH AND MOIST, PERMAFROST

ECOREGION 2 a + b BLACK SPRUCE-FEATHERMOSS-WHITE BIRCH

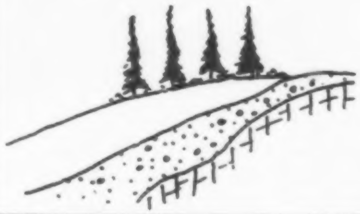
MAPPING SYMBOL Ch f-m

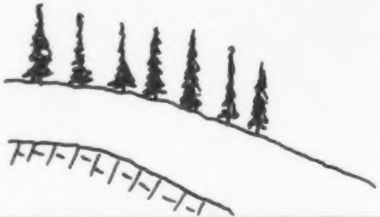
PHYSIOGRAPHIC POSITION AND LANDFORM



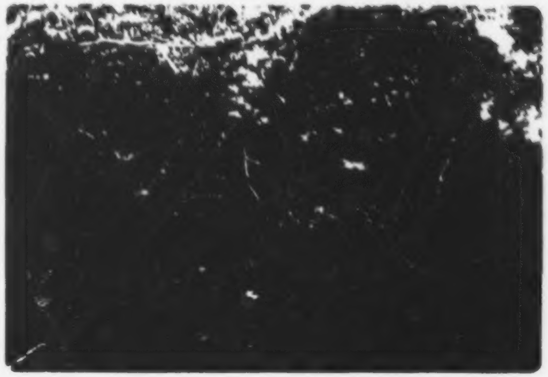
PERMAFROST

Depth of active layer 3 to 4 feet. Thickness of permafrost layer not known, but expected to be relatively thin. Amount of ice less than 50%.





SOIL CHARACTERISTICS



Cryic* Gray Luvisols, Cryic* Eutric Brunisols, or Cryic* Orthic Regosols characterized by a hummocky micro-relief. Soil hummocks measure about three feet in diameter and consist of a mount and a groove portion. These soils may or may not contain permafrost or bedrock within 40 inches from the surface. They have developed on moderately to very strongly calcareous, medium and fine textured lacustrine and till materials. Sites SI17, BT15, 18, 39, 46 and 47 are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL $\frac{Ch}{f\text{-}m}$

FOREST COVER

Black spruce occurs in most of these ecosystems. White birch may be introduced after fire as a component, but Black spruce usually constitutes part of the stand. Mature stands of Black spruce are semi closed; heights of trees may reach 30-35 feet, diameters are from 4-4.5 inches. Density about 100 square feet per acre (total), with 70 square feet per acre merchantable; crown closure varies considerably.

UNDERSTORY AND GROUNDCOVER

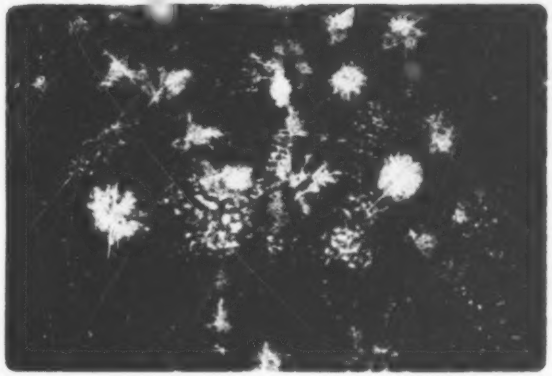
Alnus crispa and Willow occur commonly in open parts of the stands. Heights vary from 3-10 feet. Other common vegetation consists of the feathermosses: Pleurozium schreberi and Hylocomium splendens and the lichen Cladonia rangiferina and C. alpestris. Hyphnum and Dicranum spp., Petasites palmatus, Ledum groenlandicum, Vaccinium vitis-idaea, V. myrtilloides, V. uligonosum, Equisetum sylvatium and Peltigera aphthosa occur less frequently.

SUCCESSION

After fire, a mixture of Black spruce and White birch is most common. A quickly repeated burn may result in White birch being the dominant forest cover, mixed often with Salix spp., Alnus crispa and Black spruce. The proportion of Ledum groenlandicum may also increase. Herbs found can be Petasites palmatus, Ribes glandulosum, Epilobium angustifolium, Viburnum edule and Rosa spp.

SENSITIVITY

Flooding and likely construction will cause the permafrost to melt, resulting in some collapsing if permafrost present. Erosion will cause the slumping of the mounts. Where bedrock is close to the surface, a new shoreline is likely to develop in relatively short time otherwise erosion may continue for a considerable period of time.



Burnt over area. Note the light colored mounts.

Close up of mounts. The area is void of vegetation because of cleaning and pedestrian traffic (S.I.L. settlement).

ECOSYSTEM

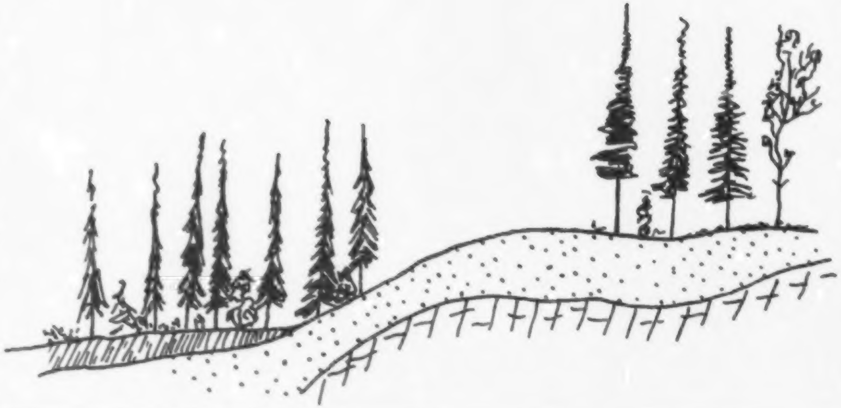
ECOREGION 2a, b & 3

SANDY TILL; DRY - FRESH
BLACK SPRUCE - LICHEN

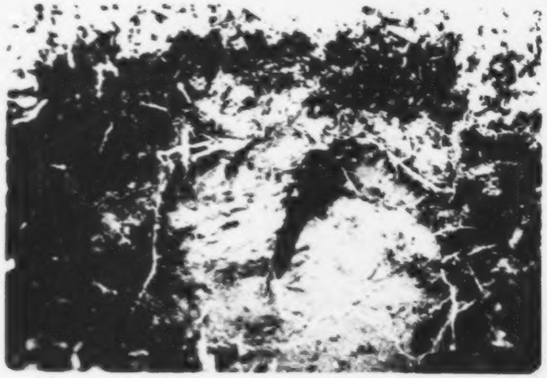
MAPPING SYMBOL S; S/R d-f

PHYSIOGRAPHIC POSITION AND LANDFORM

Zone 2a



SOIL CHARACTERISTICS



Degraded Dystric and Eutric Brunisol soils characterized by a thin L-H horizon, and underlain by weakly to moderately developed granular, light gray Ae and granular, reddish brown Bm horizons. These soils are bouldery, loamy sand textured, non-calcareous, and shallow; Precambrian bedrock occurring usually within 20 inches of the surface. Descriptions and analyses of sites BT 14, BT 21, and SI 20 are representative of these areas.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL S; S/R d-f

FOREST COVER

Open Black spruce, lichen stand in zone 2a, and semi-closed stand of Black spruce and Jack pine with some Trembling aspen and White birch in the middle (2b) and southern (3) zone. Tree growth varies with zone and within a zone. Heights of trees from 20-40 feet, with diameters of about 4.5" on the average and basal areas as low as 30 square feet per acre. No seedlings or shurbs were observed on the sampled sites in the northern zone.

UNDERSTORY AND GROUNDCOVER

In zone 2a Cladonia alpestris, C. rangiferina and other lichen form extensive coverages. Associated with them are Vaccinium spp. like V. myrtilloides, V. vitis-idaea and V. Uligonosum, and in small proportions Geocaulon lividum, Empetrum hermaphroditum and Ledum groenlandicum. In the middle (2b) and south (3) zone an increasing amount of shrubs like Alnus crispa, White birch and species mentioned under (2a).

SUCCESSION

After fire,Black spruce may regenerate again. When Jack pine seed is available a Jack pine fire regeneration will develop and the stand will transfer to Black spruce with time.

SENSITIVITY

These areas are marginally suitable for residential building, but provide a good source for road building material.

These areas are of low sensitivity to disturbance in the form of flooding and erosion. Good beaches may be formed because of shoreline erosion, provided the original slopes are not too steep.

Zone 2a
Open Black spruce with thin litter, lichen and Vaccinium spp. ground cover.

Zone 3
Note the much heavier shrub component of the system.

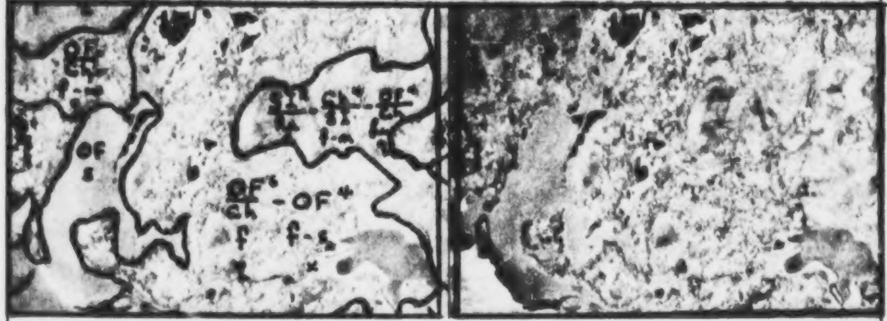
ECOSYSTEM

SHALLOW ORGANIC over LACUSTRINE, DOMED PERMAFROST
BLACK SPRUCE - FEATHERMOSS

MAPPING SYMBOL OF/Ch f-m

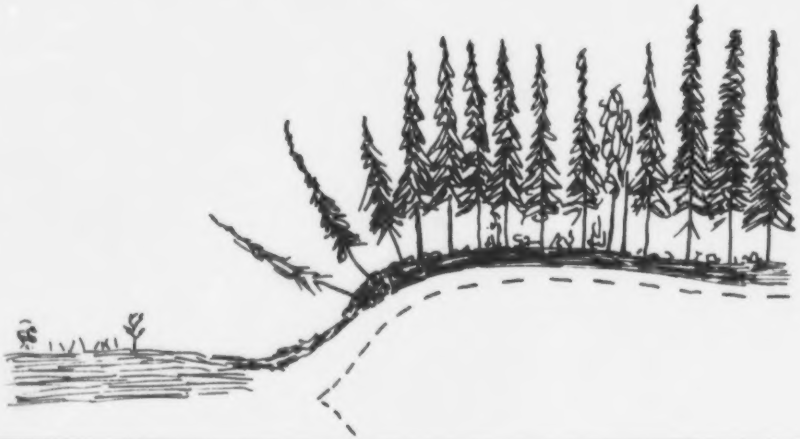
ECOREGION 2b, 3

PHYSIOGRAPHIC POSITION AND LANDFORM



PERMAFROST

As result of permafrost the landform is domed (palsa). Depending on thickness of the organic layer the uppermost layer of the permafrost occurs either in the mineral or in the organic and mineral soil.
The ice content is generally less than 50 per cent.



SOIL CHARACTERISTICS

Gleyed Cryic Orthic Regosol, -Orthic Gray Luvisol, Cryic Fibrisol, -Mesisol, and -Humisol soils characterized by a domed macro relief, the presence of a surface organic horizon more than 12 inches thick, and permafrost normally within two feet of the land surface. The domes or palsas may be eluviated over ten feet above the surrounding land surface.
Sites BT 1, 43, 44, 45, SI 18, 22, and NH 3 are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL OF/Ch f-m

FOREST COVER

Black spruce occurs on most of these landforms. In some cases, White spruce can be found, but often mixed with Black spruce. When disturbed by fire, White birch and Trembling aspen may form the forest cover or part of the cover. Tree growth can be fairly good to good, with three heights of 30-60 ft. at 100+ years of age. Diameters will be from 5-7" (in the case of White spruce 12+ inches) and basal areas may be as high as 140 square feet per acre.

UNDERSTORY AND GROUNDCOVER

Tall shrubs like Salix spp. and Alnus crispa may occur. Ledum groenlandicum occurs in various proportions. Cornus canadensis can form an extensive groundcover. Other species forming part of the system are: Rubus chamaemorus, Viburnum edule, Vaccinium vitis-idaea, Geocaulon lividum, Mitella nuda, Linnaea borealis, Pyrola virens, Moneses uniflora, Equisetum spp., Pleurozium schreberi, Hylocomium splendens, Hyphnum crista-castrensis, Dicranum spp., Cladonia spp.

SUCCESSION

After fire, Trembling aspen and/or White birch may form the tree cover, provided that the fire does not cause the melting of permafrost. Shrubs like alder will increase in proportion too. Black spruce and/or White spruce (in some areas) will form the climax and Black spruce especially will establish itself very soon.

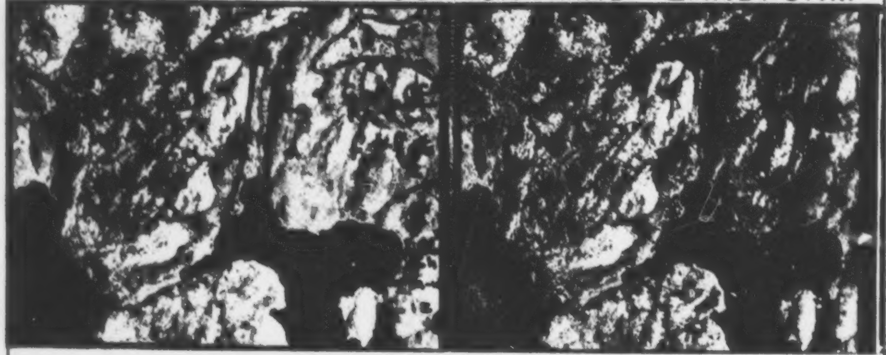
SENSITIVITY

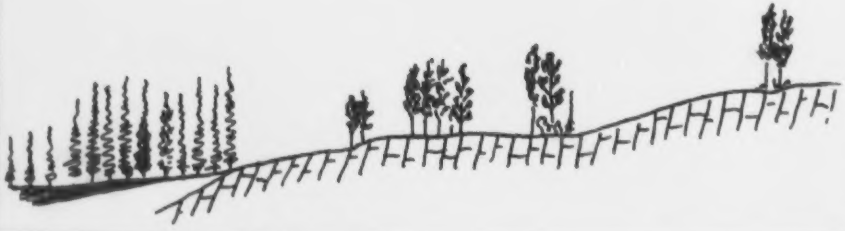
Highly sensitive to flooding, erosion and fire. As result of flooding, the permafrost will melt. This will result in extensive collapsing and slumping. It is expected that construction will have the same effect. New stable shorelines will take a long time to establish.

Collapse edge of clay palsa.
Collapse (sedge covered) in foreground.

ECOSYSTEM ECOREGION 2b, 3	PRECAMBRIAN BEDROCK, DRY JACK PINE - LICHEN	MAPPING SYMBOL Ra d

PHYSIOGRAPHIC POSITION AND LANDFORM





SOIL CHARACTERISTICS

The soil, if any, consists mainly of organic material in various stages of decomposition. Such soils are classified as Follisols if the L-H horizon exceeds 4 inches in thickness; if not, they are designated as bedrock.

Site NH 12 (profile #77) is representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL Ra
d

FOREST COVER

The forest cover, if any, consists mainly of Jack pine with various proportions of Black spruce. The amount of Black spruce increases as the amount of unconsolidated materials increases. The trees are mostly in groups, rooting in accumulated organic matter or mineral materials (often of colluvial nature or in the form of weathered rock). Trees show little height growth and small diameters, although young trees look rather vigorous.

UNDERSTORY AND GROUNDCOVER

Jack pine and Black spruce regeneration can be found. Alnus crispa growth in wet depressions with organic accumulation. Lesser vegetation is scarce. Patches of mainly Pohlia nutans, Pleurozium schreberi and sometimes Sphagnum spp. occur. The bedrock is either void of vegetation, or covered with crustose lichen spp., or a thick carpet of Cladonia rangiferina and C. alpestris. The latter condition tends to result in accumulation of organic and weathered mineral material, which provides an initially favourable medium for the establishment of tree vegetation. Other species encountered are: Vaccinium myrtilloides, Potentialla tridentata and Rubus strigosus.

SENSITIVITY

Not sensitive to flooding, construction or erosion. New shorelines will be established in short order; although trees may remain standing for some time, but probably not very long.

Bare bedrock with crustose lichen and some other vegetation.

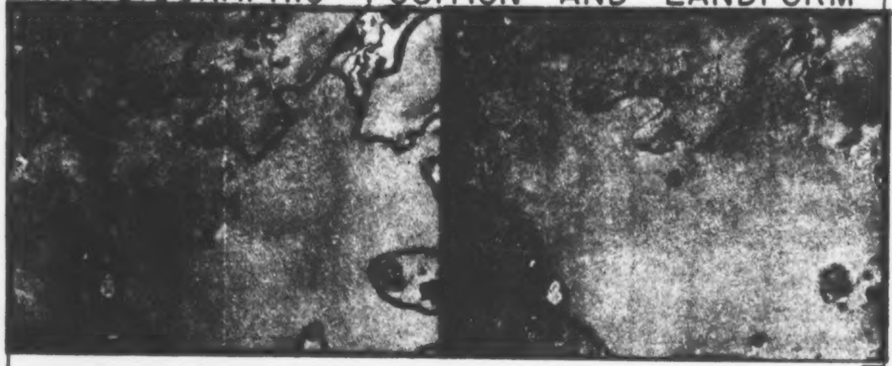
Young Jack pine and Black spruce growing in slight depression in bedrock outcrop. Note abundance of lichen on the bedrock.

ECOSYSTEM
ECOREGION 3, 2b

DEEP MESIC ORGANIC, SATURATED
SEDGES WITH STUNTED TAMARACK

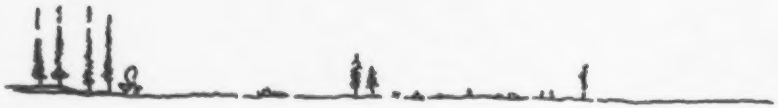
MAPPING SYMBOL $\frac{OM}{s}$

PHYSIOGRAPHIC POSITION AND LANDFORM

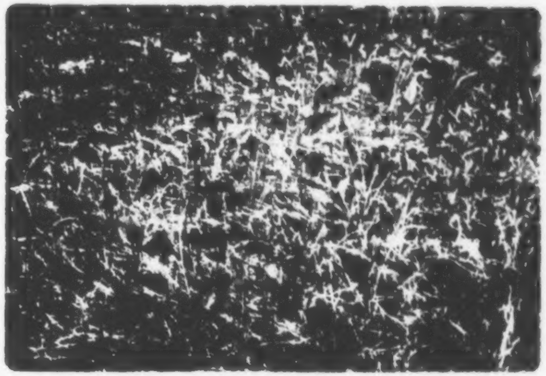


PERMAFROST

Permafrost only in associated ecosystems (palsas and peat plateaux and along the edges.



SOIL CHARACTERISTICS



Typic Mesisols characterized by moderately well decomposed fen peat overlying moderately to strongly calcareous lacustrine clay. The thickness of the organic deposit varies from 5 to 15 feet. These soils are saturated throughout the year and are free from permafrost. Sites SI 15 and BT 29 are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL OM s

FOREST COVER

No forest cover in this system. The only tree species to be found are Tamarack and a few Black spruce which are generally only a few feet tall and ± 1" in diameter.

UNDERSTORY AND GROUNDCOVER

Salix spp. and particularly Betula glandulosa can form an extensive coverage. Carex spp. form a very important part of the plant community and form a large part of the groundcover. Some Sphagnum spp. occur especially along the edges of the system. Other plant species likely to be found are: Kalmia polifolia, Vaccinium oxycoccos, Maianthemum canadense, Equisetum hyemale, Potentilla palustris, Menyanthes trifoliata, Chamaedaphne calyculata and Andromeda glaucophyla.

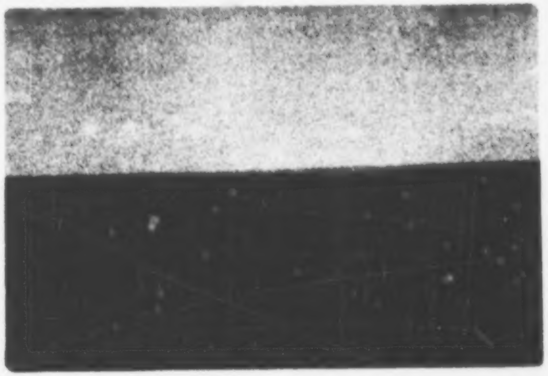
SUCCESSION

In the 2b zone this system may develop into a Sphagnum covered flat bog with an open Black spruce forest cover. Permafrost will likely develop. In the northern part of zone 3, this system may well stay the same for some time to come. In time, Sphagnum will become a more important component of the vegetation, but development of permafrost will take more time.

SENSITIVITY

No shoreline will develop in this system after flooding. Shorelines will be established in higher ground adjacent to these areas. Flooding may cause floating conditions, while subsequent wave action may erode the organic material.

Extensive sedge vegetation, with some tamarack.



More advanced stage. More tree growth, generally drier. Note the heavier treed areas which contain permafrost.

ECOSYSTEM

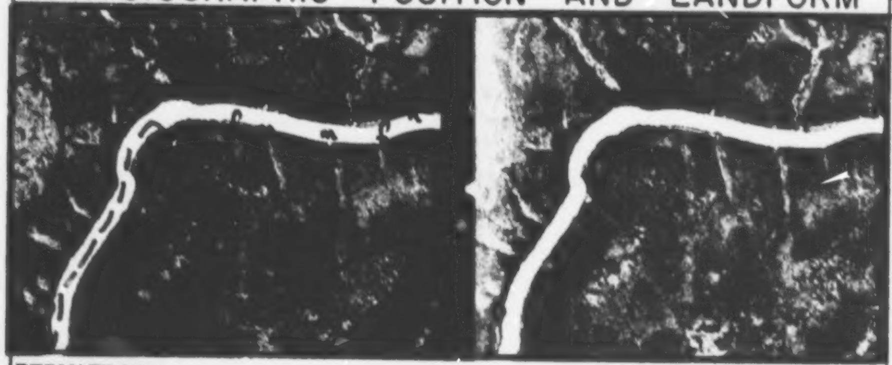
LACUSTRINE (/BEDROCK),FRESH AND MOIST, (PERMAFROST)

BLACK SPRUCE - FEATHERMOSS

ECOREGION 3

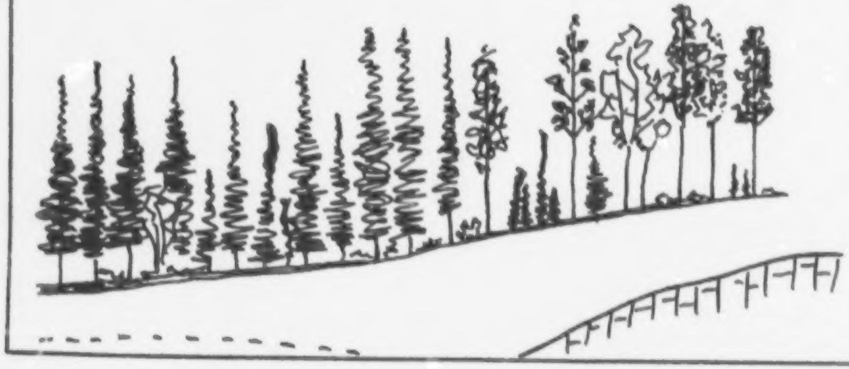
MAPPING SYMBOL $\mathrm{Iv,Ch,}\frac{\mathrm{Ch}}{\mathrm{Ra}}$ $_{\text{f-m}}$

PHYSIOGRAPHIC POSITION AND LANDFORM



PERMAFROST

Permafrost is not very common in these landforms. When encountered it is found in the moist locations, where the L.F.H. layer is somewhat thicker than normal. In those cases permafrost can be found within 6 feet. On the upland sites pf. is either not present or below 6 feet. The content low.



SOIL CHARACTERISTICS

Orthic Brunisols and Orthic Gray Luvisols characterized by a relatively thin solum consisting of a thin L-H horizon underlain either by a brown Bm horizon or by a light gray platy Ae and a brown, subangular blocky Bt horizon. These soils have a medium to fine texture, having developed on stratified lacustrine silt and clay deposits. Sites T1, 5, 11, BT37, MM2 and 9 are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL Iv,Ch,$\frac{Ch}{Ra}$ f-m

FOREST COVER

Black spruce occurs in most of these ecosystems. In many cases, however, this cover is replaced by Jack pine, White birch and/or Trembling aspen as a result of fire. Black spruce will often form part of the cover or will be present in the understory. Close to lakes and rivers White spruce may form mixed stands with Black spruce and/or Trembling aspen. Mature stands of Black spruce will be relatively dense. Average height of the stands is between 40 and 50 feet at 80-100 years of age. Diameters are between 5 and 8" and basal areas are around 100-110 square feet per acre.

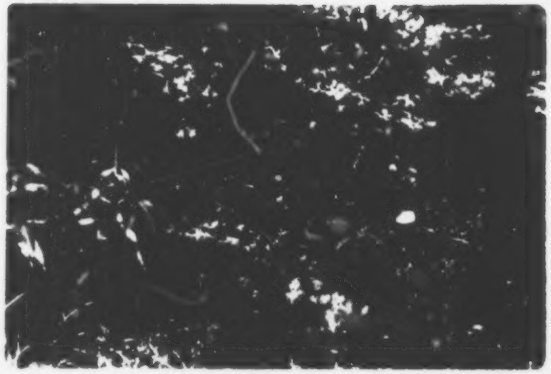
UNDERSTORY AND GROUNDCOVER

Salix spp. and Alnus crispa shrubs occur throughout the stands and may reach heights greater than 10 feet. Black spruce layering in climax Black spruce stands or regenerating in stands of Jack pine can be found throughout, the latter situation occuring most frequent. Ledum groenlandicum, Vaccinium vitis-idaea, V. myrtilloides, V. oxycoccos, Cornus canadensis, Rosa acicularis, Equisetum sylvaticum,Achillea borealis, Epilobium angustifolium, Fragaria spp. can be found throughout, but the number vary from place to place. Mosses, like Pleurozium schreberi, Hylocomium splendens, Hypnum crista-castrensis and Pohlia nutans constitute the dominant groundcover.

SENSITIVITY

Sensitive to flooding, erosion and construction.
Silt laminae, when present, are apt to liquifaction.
Permafrost, if any, will melt out upon disturbance, resulting in collapsing.
New shorelines will take a long time to develop into stable ones. Vegetation may remain standing for a considerable period of time.

Jack pine mixed with some Black spruce and Trembling aspen. Note good bS-regeneration.



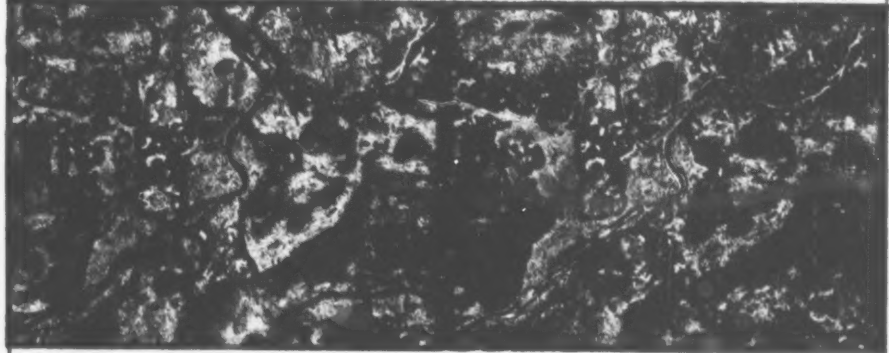
Groundcover of feathermoss plus some lichen,strawberry and fireweed.Fresh to moist.

ECOSYSTEM DEEP FIBRIC-OR FIBRIC OVER MESIC ORGANIC

ECOREGION 3 SPHAGNUM-TAMARACK-BLACK SPRUCE

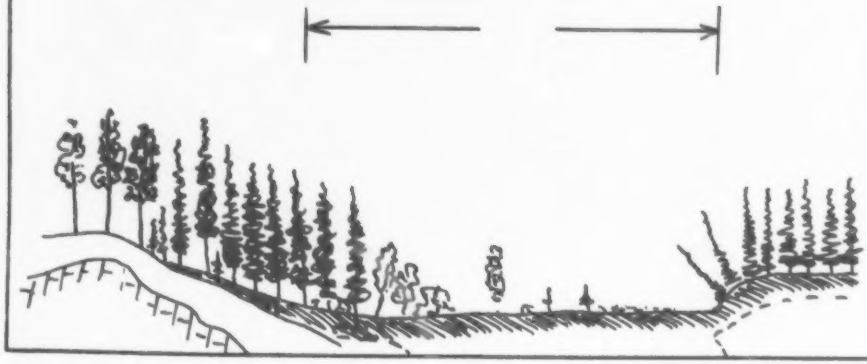
MAPPING OF $\frac{OF}{OM}$
SYMBOL w-s

PHYSIOGRAPHIC POSITION AND LANDFORM



PERMAFROST

The permafrost peat landforms are really different ecosystems but are in mapping often included with this ecosystem. The permafrost is found in the raised peat-bodies (palsas and peat plateaus) and often along the edges of this ecosystem.



SOIL CHARACTERISTICS

Sphagno-Fibrisols and Mesisols characterized by thin to thick (16-52"), relatively undecomposed sphagnum peat underlain by either relatively undecomposed sphagnum peat or moderately well decomposed forest and/or fen peat. These soils are very poorly drained and are free of permafrost. Sites SI19b, 22 and MM8b are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING OF $\frac{OF}{OM}$
SYMBOL w-s

FOREST COVER

There is no continuous tree cover. Isolated or small group of trees may occur. Tree species are Tamarack and Black spruce with some White birch. The trees are usually stunted.

UNDERSTORY AND GROUNDCOVER

There can be an extensive cover of Betula glandulosa. Salix spp. tend to concentrate along the edges of the unit. Sphagnum spp. form an extensive, often hummocky cover. The tops of the hummocks are usually dry, but between the hummocks open water may occur. Other ground cover such as Pleurozium schreberi and Cladonia spp. may be found growing on the hummocks. Associated vegetation includes: Ledum groenlandicum, Chamaedaphne calyculata, Rubus chamaemorus, Carex spp., Equisetum hyemale, Potentilla palustris, Vaccinium oxycoccos, Menyanthes trifoliata.

SUCCESSION

This type of peatland is in a more advanced stage than the one described under OM. As a result of the sphagnum build up a raised bog will eventually develop, which will have a drier surface and a more continuous tree cover composed of Black spruce. Under suitable climatic conditions permafrost may form in the organic material, which will turn the landform into a palsa or peat plateau.

SENSITIVITY

Highly sensitive to flooding and erosion and unsuitable for construction purposes. Flooding will likely cause flotation of the organic material. If but partially flooded, gradual erosion will take place resulting in new stable shorelines, which will take a long time to develop.

Along Rat River. Note the abundant Willow growing on slightly better drained sites.

Sphagnum fen. Note the collapsed palsa on the left. View from palsa with collapse edge.

ECOSYSTEM

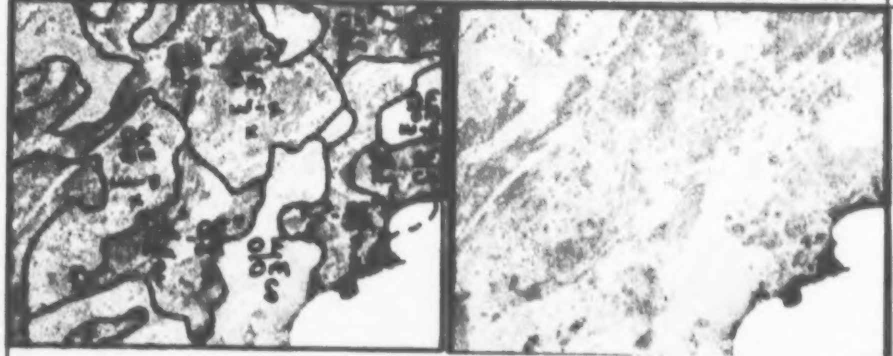
ECOREGION 3

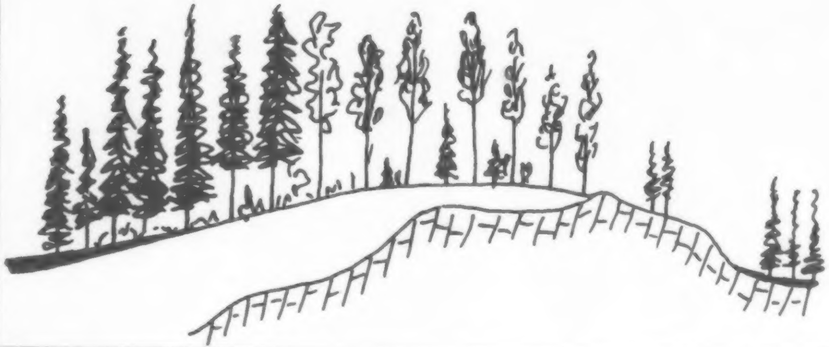
LACUSTRINE OVER BEDROCK. DRY to MOIST

BLACK SPRUCE/JACKPINE-FEATHERMOSS-LICHEN

MAPPING SYMBOL $\frac{\text{Ch}}{\text{Ra}}$ d - m

PHYSIOGRAPHIC POSITION AND LANDFORM





SOIL CHARACTERISTICS

Orthic Gray Luvisol and Degraded Eutric Brunisol soils developed on stratified lacustrine silt and clay deposits and underlain by bedrock within 40 inches of the mineral surface. These soils are characterized by a thin L-H horizon underlain by a light gray Ae horizon and a brown Bm or Bt horizon. The upper part of the Luvisolic Bt horizon usually has a strong subangular blocky structure and the peds may have light gray exterior colours. Sites NH12a, 13 and 23 are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL $\frac{\text{Ch}}{\text{Ra}}$ d - m

FOREST COVER

Climax forest is Black spruce. However, it is often mixed with Jack pine. Close to lakes, the associated species are Trembling aspen and White spruce. Stands rate from fair to good, depending on the thickness of the mineral soil and the drainage. Heights 40 to 60 feet at 100 years and diameters up to 12". Basal areas of 80-140 square feet per acre can be expected.

UNDERSTORY AND GROUNDCOVER

Alnus spp. is the most common shrub encountered on these sites. Rosa acicularis, Epilobium angustifolium, Cornus canadensis, Geocaulon lividum, Lonicera canadensis, Vaccinium myrtilloides, Petasites, palmatus, Linnaea borealis, Pyrola virens, Fragaria vesca, Ledum groenlandicum, Arctostaphylos uva-ursi, occur in small numbers (less than 5% cover). Pleurozium schreberi, Hylocomium splendens Cladonia rangiferina, C. alpestris dominate the ground cover; Peltigera aphthosa, Calamagrostis canadensis and Galium boreale occurring in minor amounts.

SUCCESSION

After fire, the drier sites normally have regeneration of Jack pine and more moist sites of Trembling aspen. Black spruce will establish itself rather quickly in the form of understory regeneration and will eventually take over. White birch also occurs in sub-seral stands. In areas where bedrock is close to the surface, Jack pine may form more than one generation, even when site remains undisturbed.

SENSITIVITY

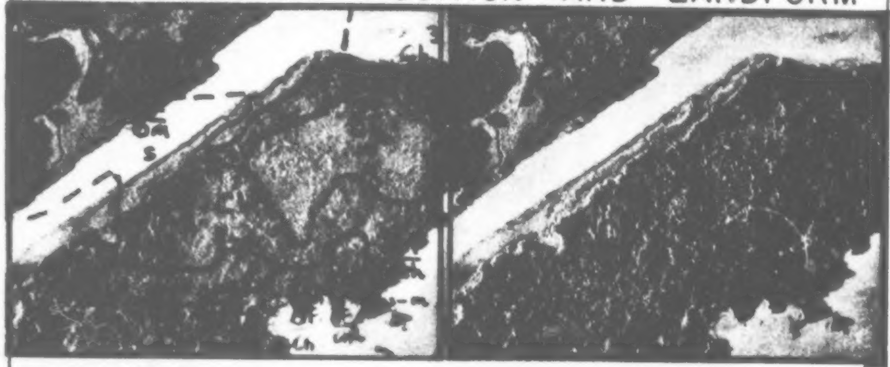
These ecosystems are moderately sensitive to construction, flooding or erosion. The new shoreline will be controlled by bedrock. Depending on the depth of the clay the time period required for the development of stable shoreline will vary.

Black spruce overmature. Bedrock close to the surface.

Stand of overstocked Black spruce on deeper clay over bedrock. Good height-growth.

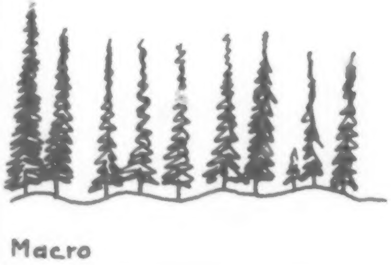
ECOSYSTEM ECOREGION 3	ORGANIC OVER CLAY,PERMAFROST BLACK SPRUCE-SPHAGNUM-FEATHERMOSS	MAPPING $\frac{OF}{Ch}$ SYMBOL w - m

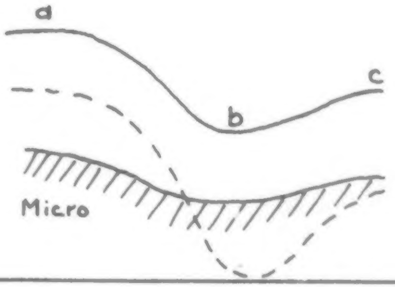
PHYSIOGRAPHIC POSITION AND LANDFORM



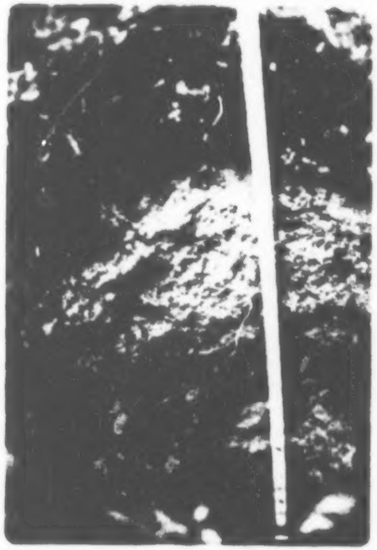
PERMAFROST

The depth of the active layer varies with the configuration of the micro relief. When there is a good insulative hummock of sphagnum peat(a) the permafrost will be found within 20". When the peat layer is more shallow(b) no pf. will be encountered within 40" from the surface. When the active layer is deeper, pf. found only in the mineral soil. The density has also a distinct effect.





SOIL CHARACTERISTICS



Gleysolic soils characterized by a thick organic horizon underlain either by relatively unaltered parent material or by a thin dark coloured Ah horizon, a light gray Ae horizon and a dull-coloured B horizon. The organic horizon usually consists mainly of sphagnum peat. These soils have a medium to fine texture, having developed on clayey lacustrine deposits. Permafrost may be encountered below a depth of 40 inches. Site BT38 is representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL $\frac{OF}{w^{Ch}m}$

FOREST COVER

Picea mariana forms the tree cover on these landforms. The growth will vary widely as a result of drainage conditions, thickness of active layer and the depth of the mineral soil.

UNDERSTORY AND GROUNDCOVER

Often good regeneration of P. mariana. Tall shrubs are not common on this landform. Other vegetation includes: Ledum groenlandicum, Rubus chamaemorus, Vaccinium vitis-idaea, in various proportions. Sphagnum spp. (especially fuscum) and Pleurozium schreberi form the building material of the organic material. Cladonia rangiferina and alpestris occur on top of the organic hummocks.

SUCCESSION

The stable tree cover is P. mariana which will regenerate and form the tree cover for many rotations. These landforms may, however, become over mature, that is, the permafrost may melt out which causes collapsing and much wetter conditions and a new different ecosystem will be formed. This melting out of permafrost will occur quite likely after a disturbance such as a fire.

SENSITIVITY

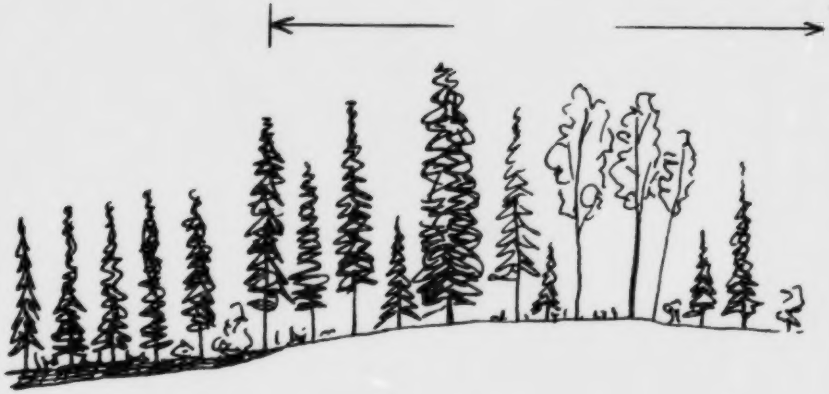
These ecosystems are very sensitive to flooding and construction. The permafrost will melt and as a result collapsing will follow. The vegetation will remain in a standing position long after flooding and new stable shorelines will take a long time to develop

Oblique view of ecosystem Better tree growth than generally found.

More common bS-stand in this ecosystem. Note: sphagnum hummocks.

ECOSYSTEM	LACUSTRINE, MOIST AND FRESH	MAPPING Ch
ECOREGION 3	BLACK SPRUCE-FEATHERMOSS	SYMBOL$_{m}$ - f

PHYSIOGRAPHIC POSITION AND LANDFORM



SOIL CHARACTERISTICS

Orthic- and Solodic Gray Luvisols characterized by a thin L-H horizon underlain by a light gray Ae horizon and a brown Bt horizon. The Ae horizon of Orthic Gray Luvisols normally have a shot-like structure and their Bt horizon is subangular blocky. The Solodic Gray Luvisols are characterized by a platy structure in the Ae horizon and a columnar macro-structure in the upper Bt horizons. These soils usually have a heavy clay texture. Sites T12, BT2, MM8a, 10, NH1, 2, 4, and 6 are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL Ch m-f

FOREST COVER

The climax forest cover is Black spruce. In many cases the stands are not pure and may contain Jack pine and White birch. On suitable sites (modified microclimate) the mixture may include White spruce and Trembling aspen. The Black spruce may be as high as 50-60 feet at 100 years of age, with diameters between 6 and 12", and basal areas between 100-150 square feet per acre. White spruce may be over 70 feet tall at 100+ years with diameters up to 20+ inches.

UNDERSTORY AND GROUNDCOVER

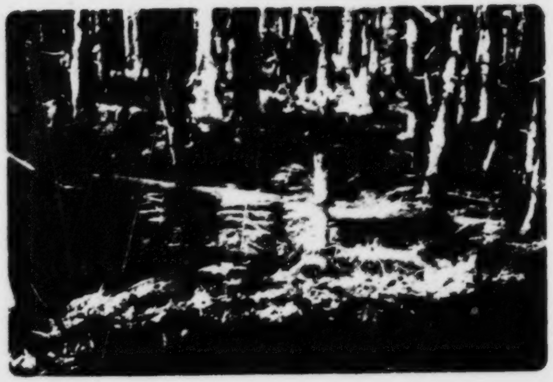
Salix spp. and White birch frequently occur as tall shrubs in the understory. Pleurozium schreberi, Hylocomium splendens and, to a lesser extent, Hypnum crista-castrensis may form an extensive groundcover. Often encountered with these mosses are patches of Cladonia spp. and some Peltigera aphthosa. Other vegetation consists of: Rosa acicularis, Epilobium angustifolium, Vaccinium myrtilloides, V. vitis-idaea, Fragaria vesca, Linnaea borealis, Cornus canadensis, Pyrola virens, Rubes pubescens, Viburnum edule.

SUCCESSION

The stable and climax vegetation is Black spruce or a mixture of Black and White spruce. After disturbance by fire, a treecover of Jack pine, Trembling aspen and/or White birch may develop. Soon Black spruce regeneration will establish itself and will eventually take over.

SENSITIVITY

Fairly sensitive to flooding and erosion. Vegetation will likely remain standing for a long time and the establishment of a new stable shoreline will take a long period of time.

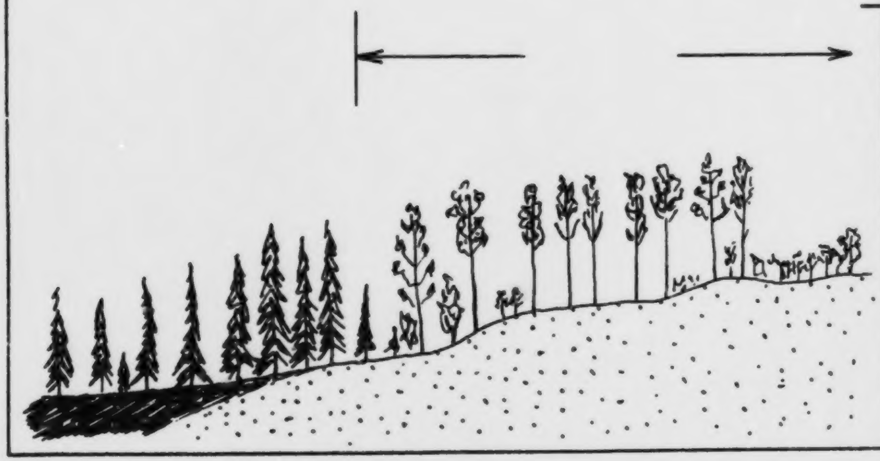


Mature Black Spruce on moist clay.

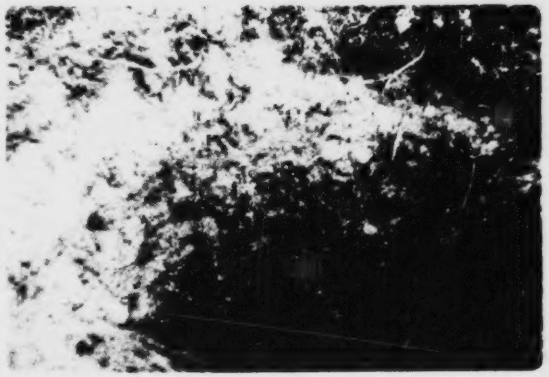
Very good Trembling aspen mixed with Black spruce and some White Spruce on fresh site.

ECOSYSTEM **ECOREGION** 3	GLACIO-FLUVIAL OUTWASH, DRY JACK PINE - LICHEN	**MAPPING SYMBOL** $\frac{G1}{d}$ $\frac{S1}{d}$

PHYSIOGRAPHIC POSITION AND LANDFORM



SOIL CHARACTERISTICS



Degraded Dystric Brunisols characterized by a thin L-H horizon, underlain by a distinct, light gray, strongly acid Ae and a friable, brown to reddish brown Bm horizon.

These soils have a medium sandy texture, having developed on beach deposits and on lake modified, glacio-fluvial deposits derived from Precambrian rock. The parent material tends to be weakly calcareous at three feet depth.

Sites T4, MM8a, and SI 18 are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL
G1 S1
d d

FOREST COVER

Jack pine occurs frequently on these sites as a result of fire and of highly permeable soil materials. Black spruce may form part of the forest cover, as may White birch. Tree growth varies from poor to fairly good, depending on coarseness of the soil material and depth of the water table. Heights vary from 40-55 feet at 150-200 years with diameters between 10 and 12" and basal areas of 100 to 110 in better stands of Jack pine.

UNDERSTORY AND GROUNDCOVER

White birch and Alnus crispa may occur as shrubs in stands. Most of the ground is covered with litter. The moss layer **is not extensive**; some Pleurozium schreberi and Pohlia nutans will occur together with Cladonia rangiferina. The amount of mosses will increase with improvement in moisture conditions. Other plant species most likely to be found are: Epilobium angustifolium, Vaccinium myrtilloides, V. vitis-idaea, Arctostaphylos uva-ursi, Viburnum edule.

SUCCESSION

These areas are very prone to fire. As a result, tree cover is in most cases Jack pine. If no disturbance occurs, the stand may perpetuate itself into another Jack pine stand or may convert into a mixture of Jack pine and Black spruce. Invasion of Black spruce occurs especially in areas which border lower lying areas where Black spruce forms the forest cover.

Open mature Jack pine stand. Note the dense jP regeneration in the background.

SENSITIVITY

These landforms constitute good sources of sand and gravel for construction purposes.
These ecosystems are not too sensitive to flooding and erosion. Sandy beaches may form readily provided the original slope is not too steep.

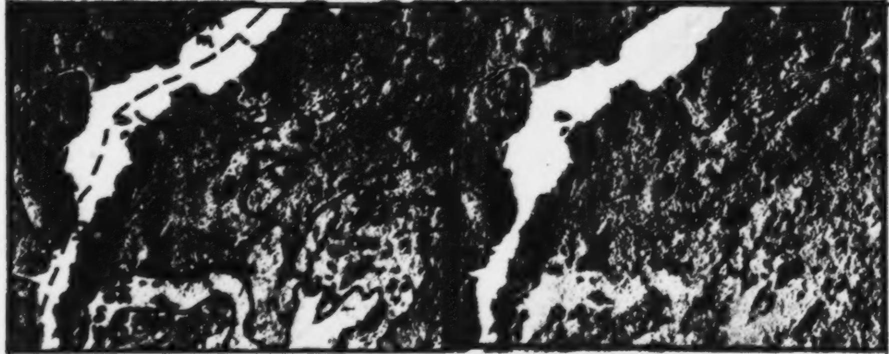
Groundcover: Forest litter, some mosses and Vaccinium spp.

ECOSYSTEM FIBRIC OVER MESIC ORGANIC, FIBRIC-AND MESIC ORGANIC,-PERMAFROST

ECOREGION 3, 4 BLACK SPRUCE - SPHAGNUM

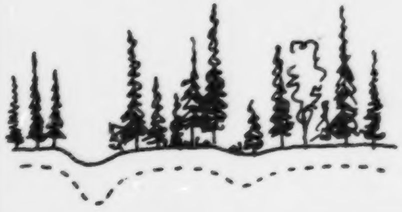
MAPPING SYMBOL $\frac{OF}{OM}$, OF, OM W-s

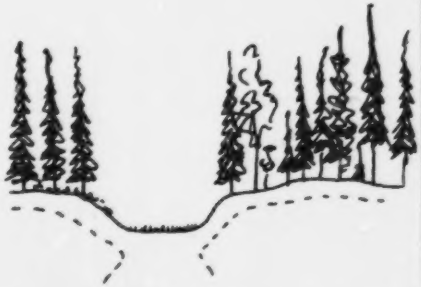
PHYSIOGRAPHIC POSITION AND LANDFORM



PERMAFROST

The upper limit of the permafrost is wavy. The depth of the active can vary considerably over short distances. The depth of the active layer usually within 15 to 32 inches. The permafrost is often not continuous in these systems, in many places the p.f. has melted causing collapses of various sizes.





SOIL CHARACTERISTICS

Cryic Humisols,-Mesisols, or-Fibrisols characterized by a level or domed macrorelief and the presence of permafrost usually at about 18 inches from the land surface. These organic soils are moderately well drained when domed owing to upheaval by permafrost, and are usually surrounded by a collapse scar. They consist of thick to very thick organic accumulations comprised by either sphagnic, forest, or fen peat or a combination of these materials. Sites Bt3, NH7a, 7b and 8 are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL $\frac{\text{OF}}{\text{OM}}$, OF,OM
w-s

FOREST COVER

The forest cover is mainly Black spruce, sometimes mixed White birch. Even Trembling aspen and White spruce are found on some of these sites. Growth will vary considerably as a result of drainage, type of peat and depth of active layer. In most cases growth is not too impressive. For Black spruce 25-50 feet in 100 years with diameters of 2.5-8 inches and basal areas of about 100 square feet per acre.

UNDERSTORY AND GROUNDCOVER

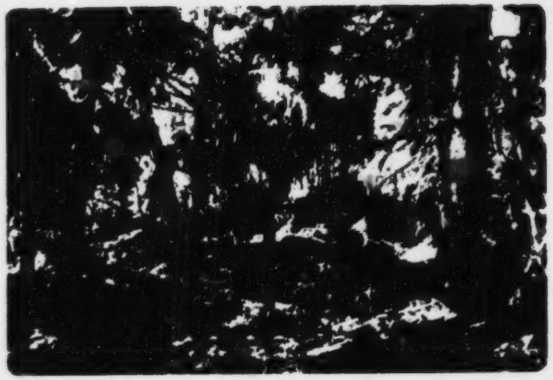
Salix spp. and White birch often occur in the understory. Ledum groenlandicum may form an extensive cover but constitutes often only a lesser part of the vegetation. Sphagnum spp. comprise up to 80+% of the moss layer, Pleurozium schreberi being an important associate. Other vegetation includes: Rubus chamaemorus, Chamaedaphne calyculta, Linnaea borealis, Hylocomium splendens, Dicramum fuscescens, Cladonia rangiferina and C. alpestris.

SUCCESSION

The stable vegetation is Black spruce with minor inclusions of White birch and sometimes White spruce and Trembling aspen. After fire the amount of White birch will likely increase, however Black spruce regeneration will be abundant. Melting of the permafrost because of disturbance will result in the development of a completely different ecosystem.

SENSITIVITY

These ecosystems are very sensitive to flooding and construction. Permafrost will melt, resulting in collapsing. Flooding will probably cause floating-bog conditions. It will take a long time before a new stable shoreline will be established.



Good uneven-aged Black spruce on moist site.

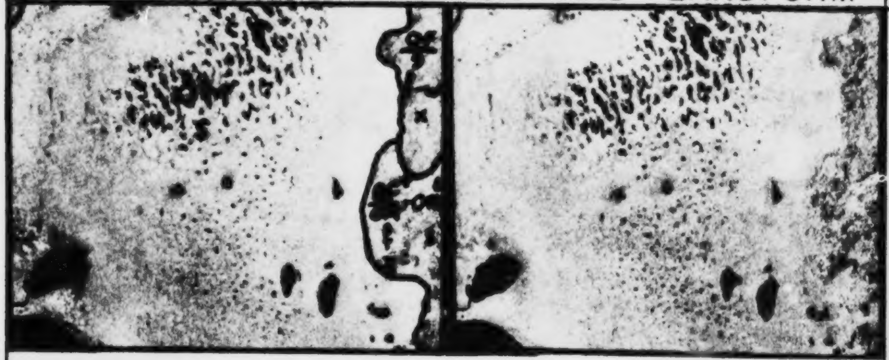
Black spruce over feather-mosses. Permafrost in hummocks; in depressions open water.

ECOSYSTEM DEEP MESIC ORGANIC, SATURATED

ECOREGION 3, 4 SEDGES WITH STUNTED TAMARACK

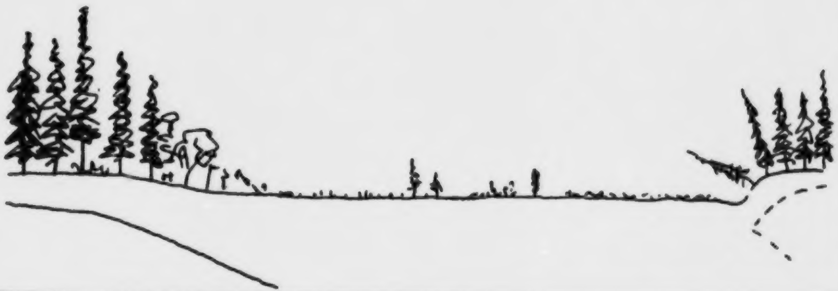
MAPPING SYMBOL OM
s

PHYSIOGRAPHIC POSITION AND LANDFORM



PERMAFROST

No permafrost in these systems. However these systems are often associated with palsas and peat plateaus, which are higher than the surrounding area and contain permafrost.



SOIL CHARACTERISTICS

Typic- and Terric Mesisols characterized by thick to very thick, moderately decomposed fen peat overlying moderately to strongly calcareous lacustrine clay. This mesic peat is derived mainly from sedges and rushes. The ridges of patterned fens usually have a thin, discontinuous layer of undecomposed, sphagnum-derived peat overlying the fen peat. These soils are very poorly drained and free of permafrost. Sites SI21 and NH9 and 10 are representative of these conditions.

BIOTIC CHARACTERISTICS

MAPPING SYMBOL OM_s

FOREST COVER

No tree cover.

UNDERSTORY AND GROUNDCOVER

Some stunted, very widely spaced Tamarack on horizontal fens. In the case of patterned fens, Tamarack confined to the ridges and associated with feathermosses and to some extent Sphagnum spp. Sometimes stunted Black spruce will occur. Most of the area (especially flarks in patterned fens) is very wet with a vegetation composed of: Carex spp. (large coverage), Equisetum hyemale, Drepanocladus spp., Vaccinium uligonosum, Menyanthes trifoliata, and Potentilla palustris. Betula glandulosa (and Salix spp.) can form an extensive coverage when the area is in a more advanced stage, that is, when the flarks and ridges are less distinct and the water is not at the surface.

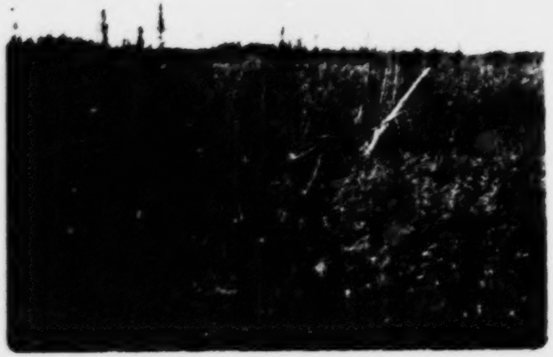
SUCCESSION

Disturbances like fire are not likely to occur and if occurring only the surface will burn. The surface of this system will become drier with time, organic accumulation raising the system above the water table. Sphagnum spp. will become more abundant and this will accellerate the raising of the system. Black spruce will move in and eventually will form at first an open tree cover which may become denser with time. Permafrost may develop, but is not very likely to happen in this region.

SENSITIVITY

Flooding is likely to result in floating bog conditions with subsequent erosion of the organic material by wave action. The shorelines will develop in higher ground adjacent to these areas.

Sedge vegetation with some stunted tamarack. In background higher ground with bS.



Extensive cover of Betula glandulosa. Area generally drier than the one pictured above.

SOIL CHARACTERISTICS IN RELATION TO ENVIRONMENTAL DISTURBANCE

The morphological and analytical soil properties of importance to certain man-made disturbances of the environment are discussed in this section. For purposes of this discussion, pertinent analytical results are presented in Tables IX, X, and XI. Specific results of physical and chemical analyses, together with their respective soil, vegetation, and site descriptions, can be obtained from the Canada-Manitoba Soil Survey, Winnipeg, upon request.

A. Susceptibility to Water Erosion

1. Runoff Erosion

Evaluations of the susceptibility of soil materials to erosion by running water are based on the results obtained for dispersion ratio analysis (Table IX). The dispersion ratio (D.R.) of a soil or material is entirely dependent on the soil characteristics. Hence, the effect of slope, vegetative cover, and rainfall intensity and duration must be considered in conjunction with the dispersion ratio values in order to evaluate the total impact of water erosion. In general, soil materials situated in areas with little or no slope and having dispersion ratio values of less than 15 per cent are relatively unaffected by runoff erosion.

The results show that the Ah and Ae horizons have a dispersion ratio percentage less than 12; with the exception of the result for Site S19. AB horizons have a value of less than 6 per cent; the 20 per cent dispersion ratio for Site BT 18a being questionable. BA horizons have dispersion ratios ranging between 7 and 19 per cent, while that of the Bt and Bnt horizons is generally less than 7 per cent. Of interest

TABLE IX

CERTAIN PHYSICAL AND CHEMICAL PROPERTIES OF HORIZONS FROM SOME SOILS OF THE STUDY AREA

Site #	Horizon	Material	Si	C	Org.C	$CaCO_3$	D.R.	B.D.		$NaHCO_3$- soluble P
								M.	DRY	
			%	%	%	%	%	g/cc	g/cc	ppm
NH1	L-H	Litter			52.5					21.4
NH2	L-H	Litter			44.3					21.6
NH4	L-H	Litter			47.7					62.0
NH5	F-H	Litter			32.6					83.0
NH6	L-H	Litter			43.3					71.0
NH12a	F-H	Litter			45.1					37.8
NH12c	L-F	Litter			52.4					36.6
NH14	L-H	Litter			43.2					33.6
NH17	F-H	Litter			53.2					42.2
NH19	L-H	Litter			53.4					24.0
NH23	F-H	Litter			56.7					28.8
T4b	Ahg	Glacio-fluvial	71	26	6.1	4.7	9.3	1.36	1.52	
BT7	Aheg	Lacustrine	40	54	14.4	-	6.2	0.81	1.01	
BT48	ACg	Lacustrine	42	51	2.1	-	3.0	1.56	1.70	
NH3	IIAC	Lacustrine			17.1					2.0
BT1	Aeh	Lacustrine	8	91	3.3	-	2.2	1.39	1.42	
BT15b	Aeh	Calc. Till	37	49	13.6	-	1.9	0.87	0.98	
T1	Ae	Lacustrine	44	52	1.8	-	2.1	1.08	1.21	
T9	Ae	Lacustrine	29	28	1.8	-	11.9	1.38	1.40	
T11	Ae	Alluvium	62	35	1.5	-	5.5	1.60	1.57	
T13	Ae	Lacustrine	14	86	0.3	-	5.6	1.61	1.54	
BT4	Ae	Glacio-fluvial	11	3	0.9	-	11.4	0.99	1.48	
BT5	Ae	Lacustrine	29	58	2.4	-	6.8	0.92	0.97	
SI1	Ae	Lacustrine	30	65	6.3	-	8.6	1.13	1.14	
SI8a	Ae	Lacustrine	26	72	2.5	-	2.9	0.85	0.95	
SI9	Ae	Lacustrine	20	79	2.7	-	31.7	0.90	0.97	

TABLE IX (continued)

Site #	Horizon	Material	Si	C	Org.C	$CaCO_3$	D.R.	B.D.		$NaHCO_3$-soluble P
								M.	DRY	
			%	%	%	%	%	g/cc	g/cc	ppm
BT12	Ae	Lacustrine	41	55	5.5	-	4.6	1.13	1.21	
BT15a	Ae	Calc. Till	38	30	5.6	-	2.4	1.31	1.32	
SI10b	Ae	Lacustrine	33	46	1.5	-	3.4	1.42	1.44	
BT18a	Ae	Lacustrine	39	57	11.5	-	9.2	1.20	1.23	
SI12	Ae	Lacustrine	31	65	2.7	-	4.6	1.43	1.45	
SI20	Ae	Colluvium	8	6	4.6	-	-	1.54	1.60	
BT35	Ae	Lacustrine	64	33	1.9	-	6.2	1.31	1.35	
NH1	Ae	Lacustrine	21	74	5.2	-	1.8	0.87	0.98	54.2
NH4	Ae	Lacustrine	27	69	3.0	-	2.3	0.86	0.97	8.4
NH5	Ae	Lacustrine	31	47	7.1	-	3.6	0.82	0.97	119.0
NH6	Ae	Lacustrine	32	65	2.4	-	3.0	0.89	1.13	5.8
NH12a	Ae	Lacustrine	50	39	3.5	-	-	-	-	3.4
NH14	Ae	Lacustrine	24	73	2.9	-	-	-	-	1.2
NH17	Ae	Lacustrine	35	59	3.8	-	-	-	-	8.6
NH19	Ae	Lacustrine	59	15	2.4	-	-	-	-	1.0
NH23	Ae	Lacustrine	55	9	2.2	-	-	-	-	
T12	IIAe	Lacustrine	26	69	5.5	-	10.0	1.12	1.54	
T9	AB	Lacustrine	23	51	1.1	-	4.5	1.54	1.54	
T13	AB	Lacustrine	15	84	0.7	-	5.7	1.53	1.54	
SI8a	AB	Lacustrine	32	64	1.0	-	4.9	1.63	1.69	
BT15a	AB	Calc. Till	42	28	3.1	-	5.3	1.23	1.42	
BT18a	AB	Lacustrine	39	57	2.0	-	20.0	1.39	1.43	
BT18b	AB	Lacustrine	36	61	6.2	-	2.4	0.87	-	
NH2	AB	Lacustrine	14	84	1.5	-	1.9	1.64	1.71	0.4
NH4	AB	Lacustrine	11	88	1.5	-	3.6	1.40	1.47	2.2
NH5	AB	Lacustrine	28	68	4.1	-	2.4	0.90	0.97	48.8
NH6	AB	Lacustrine	14	85	1.3	-	1.0	1.50	1.65	4.0
NH17	AB	Lacustrine	25	72	1.5	-	-	-	-	3.0
NH19	AB	Lacustrine	53	26	2.0	-	-	-	-	0.0

TABLE IX (continued)

Site #	Horizon	Material	Si	C	Org.C	$CaCO_3$	D.R.	B.D.		$NaHCO_3$-soluble P
								M.	DRY	
			%	%	%	%	%	g/cc	g/cc	ppm
BT1	BA	Lacustrine	6	93	1.1	-	7.0	1.47	1.53	
SI1	BA	Lacustrine	29	67	3.1	-	18.8	1.26	1.31	
BT15b	BA	Calc. Till	32	28	0.6	-	18.9	1.93	1.98	
BT7	BAg	Lacustrine	15	83	5.8	-	7.1	1.37	1.45	
BT8	BAg	Lacustrine	25	73	6.4	-	18.3	1.22	1.35	
T1	Btnj	Lacustrine	17	82	0.8	-	5.6	1.60	1.66	
BT2	Btnj	Lacustrine	9	91	0.9	-	4.8	1.48	1.60	
BT15a	Btnj	Calc. Till	37	31	1.2	-	26.3	1.78	1.89	
NH17	Btnj	Lacustrine	20	78	1.2	-	-	-	-	
T12	IIBtnj	Lacustrine	21	75	0.7	0.5	15.9	1.54	1.56	
T12	IIBt	Lacustrine	8	92	0.3	0.3	7.6	1.43	1.44	
T1	Bt	Lacustrine	7	71	0.8	-	2.5	1.65	1.65	
T9	Bt	Lacustrine	13	36	0.6	-	7.1	1.56	1.65	
T11	Bt	Alluvium	49	47	1.2	-	2.1	-	1.54	
BT2	Bt	Lacustrine	8	92	0.8	-	2.9	1.41	1.49	
SI1	Bt	Lacustrine	18	81	0.7	-	6.7	1.46	1.55	
SI9	Bt	Lacustrine	14	86	11.8	-	2.9	1.60	1.67	
BT12	Bt	Lacustrine	20	80	1.4	-	2.2	1.42	1.45	
SI10b	Bt	Lacustrine	14	84	1.6	-	4.1	1.51	1.57	
BT18a	Bt	Lacustrine	7	93	0.6	-	6.9	1.43	1.60	
BT18b	Bt	Lacustrine	7	92	0.8	-	4.3	1.37	1.64	
SI12	Bt	Lacustrine	38	53	0.8	-	4.4	1.42	1.51	
SI16	Bt	Lacustrine	14	85	2.5	-	53.8	1.51	1.65	
BT39b	Bt	Lacustrine	58	38	0.7	0.9	18.1	1.46	1.49	
NH2	Bt	Lacustrine	3	96	0.7	-	3.0	1.22	1.49	0.6
T4a	Bt1	Lacustrine	8	91	1.4	-	3.7	1.65	1.60	
BT15a	Bt1	Calc. Till	30	59	0.4	-	10.1	1.64	1.64	
BT15b	Bt1	Calc. Till	31	62	0.4	-	5.8	1.72	1.75	
NH4	Bt	Lacustrine	7	92	1.1	-	1.9	1.40	1.56	2.2
NH12	Bt	Lacustrine	29	69	0.9	-	-	-	-	1.0
NH17	Bt	Lacustrine	19	80	0.9	-	-	-	-	2.0
NH19	Bt	Lacustrine	50	32	1.2	1.1	-	-	-	0.2

TABLE IX (continued)

Site #	Horizon	Material	Si	C	Org.C	$CaCO_3$	D.R.	B.D. M.	B.D. DRY	$NaHCO_3$- soluble P
			%	%	%	%	%	g/cc	g/cc	ppm
T4a	Bt2	Lacustrine	7	92	0.8	-	3.3	1.44	1.47	
BT15a	Bt2	Calc. Till	19	33	0.3	-	22.1	1.65	1.65	
BT15b	Bt2	Calc. Till	59	34	0.3	-	17.2	1.61	1.66	
NH1	Bt2	Lacustrine	12	88	1.3	-	2.3	1.17	1.23	3.4
BT12	Bnt	Lacustrine	24	76	1.2	-	5.2	1.57	1.66	
SI12	Bnt	Lacustrine	13	86	1.0	-	4.4	1.52	1.56	
NH2	Bnt	Lacustrine	6	93	0.9	-	3.6	1.51	1.66	0.4
BT18a	Bnt1	Lacustrine	32	65	1.6	-	7.8	1.27	1.53	
BT18b	Bnt1	Lacustrine	33	63	2.0	-	15.2	1.17	1.20	
NH6	Bnt1	Lacustrine	11	88	0.9	-	2.8	1.55	1.73	1.6
BT18a	Bnt2	Lacustrine	17	82	1.0	-	4.1	1.51	1.67	
BT18b	Bnt2	Lacustrine	19	79	1.1	-	5.7	1.39	1.57	
NH6	Bnt2	Lacustrine	11	88	0.8	-	3.0	1.36	1.47	2.2
NH23	Bm	Lacustrine	51	4	0.6	-	-	-	-	0.4
NH14	Bm	Lacustrine	32	66	1.2	2.6	-	-	-	2.0
T12	Bm	Colluvium	22	74	15.1	-	2.9	0.56	0.93	
SI8a	Bm	Lacustrine	27	69	0.8	3.7	4.6	1.08	1.12	
BT39a	Bm	Lacustrine	57	39	1.4	-	7.3	1.51	1.58	
BT46b	Bm	Lacustrine	12	82	4.9	-	1.8	1.07	1.15	
BT4	Bm1	Glacio-fluvial	1	1	0.2	-	-	1.29	1.23	
BT35	Bm1	Lacustrine	59	39	1.3	-	4.5	1.26	1.30	
BT35	Bm2	Lacustrine	59	38	1.1	-	10.9	1.50	1.54	
T13	Bmg1	Lacustrine	26	73	0.3	1.3	10.3	1.40	1.49	
T13	Bmg2	Lacustrine	18	78	0.3	2.9	3.9	1.55	1.55	
BT1	Btg	Lacustrine	5	93	0.1	3.7	11.6	1.43	1.54	
BT5	Btg	Lacustrine	15	85	1.0	-	0.8	1.27	-	
NH5	Btg	Lacustrine	3	96	0.7	0.2	3.7	1.47	1.57	8.2
BT7	Btng	Lacustrine	19	79	1.0	-	10.0	1.59	1.73	
NH5	Btng		13	85	1.2	-	3.7	1.65	1.73	12.4
BT8	Btnjg	Lacustrine	24	75	2.1	-	9.4	1.62	1.76	

TABLE IX(continued)

Site #	Horizon	Material	Si	C	Org.C	$CaCO_3$	D.R.	B.D.		$NaHCO_3$-soluble P
								M.	DRY	
			%	%	%	%	%	g/cc	g/cc	ppm
T1	BC	Lacustrine	40	59	0.4	17.4	15.5	1.45	1.49	
T4a	BC	Lacustrine	21	77	0.4	12.0	6.8	1.50	1.58	
T9	BC	Lacustrine	19	21	0.4	0.9	15.7	1.84	1.71	
T10	BC	Lacustrine	53	45	6.4	27.5	2.9	0.91	0.99	
SI9	BC	Lacustrine	49	44	11.5	5.0	3.9	1.44	1.46	
BT18a	BC	Lacustrine	22	76	0.6	-	12.0	1.36	1.40	
BT18b	BC	Lacustrine	15	84	0.7	0.4	7.3	1.32	1.51	
SI12	BC	Lacustrine	30	67	1.7	-	7.2	1.51	1.56	
SI16	BC	Lacustrine	47	52	0.7	11.1	2.6	1.10	1.28	
NH12a	BC	Lacustrine	56	41	1.4	26.2	-	-	-	0.4
NH14	BC	Lacustrine	40	59	1.1	18.4	-	-	-	1.6
NH23	BC	Lacustrine	58	6	0.4	13.5	-	-	-	0.6
BT39b	BCk	Lacustrine	71	26	0.5	29.3	34.8	1.52	1.56	
BT46a	BCk	Lacustrine	60	38	3.3	29.5	3.5	0.93	0.97	
NH6	BCk	Lacustrine	21	79	0.6	10.4	7.2	1.16	1.14	0.8
BT7	BCg	Lacustrine	17	81	0.6	-	3.6	1.61	2.06	
BT5	BCkg	Lacustrine	56	38	0.6	14.3	17.8	1.39	1.42	
BT18a	Ck	Lacustrine	29	60	-	13.5	21.6	1.54	1.63	
BT18b	Ck	Lacustrine	26	69	-	13.3	-	1.41	1.50	
BT46a	Ck	Lacustrine	-	-	-	-	-	1.59	1.60	
NH2	Ck	Lacustrine	8	92	-	36.0	7.8	1.50	1.56	1.4
NH4	Ck	Lacustrine	20	80	-	23.0	19.8	1.39	1.47	2.0
NH12	Ck	Lacustrine	62	24	-	34.9	-	-	-	0.8
NH23	C1	Lacustrine	66	6	-	25.4	-	-	-	0.2
NH19	IICk2	Calc. Till	29	7	-	25.0	-	-	-	0.4
NH23	C2	Lacustrine	55	3	-	0.5	-	-	-	1.2
NH23	C3	Lacustrine	33	0	-	0.6	-	-	-	0.0
T10	Ck1	Lacustrine	83	15	3.6	42.1	4.9	1.53	1.54	
T11	Ck1	Alluvium	64	34	-	33.2	9.6	1.65	1.68	
BT35	Ck1	Lacustrine	74	23	-	23.9	32.6	1.59	1.61	

TABLE IX (continued)

Site #	Horizon	Material	Si	C	Org.C	$CaCO_3$	D.R.	B.D. M.	B.D. DRY	$NaHCO_3$-soluble P
			%	%	%	%	%	g/cc	g/cc	ppm
BT39a	Ck1	Lacustrine	81	16	-	36.3	70.3	1.64	1.66	
BT39b	Ck1	Lacustrine	85	12	-	43.0	26.6	1.51	1.56	
BT46b	Ck1	Lacustrine	-	-	-	-	-	1.49	1.53	
NH6	Ck1	Lacustrine	18	77	-	15.2	10.8	1.45	1.54	0.6
NH14	Ck1	Lacustrine	52	45	-	30.2	-	-	-	1.2
NH17	Ck1	Lacustrine	46	52	-	19.7	-	-	-	0.6
NH19	Ck1	Lacustrine	62	16	-	39.2	-	-	-	0.4
T11	Ck2	Lacustrine	52	45	-	21.3	16.3	1.50	1.54	
BT2	Ck2	Lacustrine	35	60	-	18.4	26.1	1.49	1.55	
SI16	Ck2	Lacustrine	62	36	-	25.2	-	1.54	1.70	
BT38	Ck2	Lacustrine	25	72	-	23.9	15.7	1.53	1.58	
BT39a	Ck2	Lacustrine	62	34	-	25.4	18.3	1.49	1.53	
BT46b	Ck2	Lacustrine	68	29	-	39.3	62.6	1.43	1.52	
NH6	Ck2	Lacustrine	26	74	-	18.7	11.1	1.51	1.59	0.8
NH17	Ck2	Lacustrine	73	25	-	42.1	-	-	-	1.2
T1	Ckg	Lacustrine	13	73	-	21.4	12.7	1.63	1.66	
T4b	Ckg	Glacio-fluvial	65	31	-	24.1	6.7	1.68	1.72	
T4a	C	Lacustrine	63	27	-	24.5	29.9	1.60	1.67	
T9	IICca	Calc. Till	36	15	-	14.1	10.5	1.29	1.35	
T10	Ck10	Lacustrine	43	56	-	26.2	4.7	1.58	1.60	
T10	Ck11	Lacustrine	91	7	-	39.3	47.7	1.75	1.99	
T11	Ck3	Alluvium	58	41	-	29.0	15.7	1.38	1.74	
NH17	Ck3	Lacustrine	43	55	-	27.6	-	-	-	0.6
T11	Ck4	Alluvium	47	53	-	21.9	20.5	1.45	1.51	
NH17	Ck4	Lacustrine	60	35	-	38.5	-	-	-	0.2
T12	IICk	Lacustrine	13	86	-	6.1	11.4	1.54	1.55	
T9	IICk	Calc. Till	34	13	-	10.8	8.5	1.99	2.04	
BT45	Cg	Lacustrine	5	95	-	0.6	2.7	1.50	1.59	
NH5	Ckg1	Lacustrine	6	92	-	7.3	10.8	1.56	1.65	3.4
NH5	Ckg2	Lacustrine	9	88	-	10.8	7.3	1.08	1.12	3.6
NH12	Ck(a)	Lacustrine	51	9	-	25.5	-	-	-	0.2
NH12	Ck(b)	Lacustrine	65	26	-	36.8	-	-	-	0.8
NH14	IICk2(a)	Lacustrine	16	24	-	17.5	-	-	-	0.4
NH14	IICk2(b)	Lacustrine	38	18	-	30.9	-	-	-	0.2
NH17	Ck5	Lacustrine	62	21	-	31.3	-	-	-	0.2

in the results for the latter horizons is the high percentage for Sites BT 15a and BT 15b which may well relate to the moderately to strongly calcareous till on which these soils have developed. The values obtained for Btnj horizons are like Bt horizons for some and similar to BA horizons for others. Bm and Bg horizons have dispersion ratio values of less than 10 per cent. Data for the C horizons show the greatest variability with values ranging up to 45 per cent, excluding the result for Site BT 39a.

These results indicate that materials affected by soil development are less susceptible to runoff erosion than relatively unaltered materials; i.e., C horizons. Thus, runoff erosion could be kept at a minimum if the mineral material would be left undisturbed. Retention of an organic (litter) cover on the mineral material would further reduce runoff erosion through protection of the mineral material from raindrop erosion and because of its relatively high water-holding capacity. Maintenance of an organic cover is deemed necessary on sloping areas, particularly on terrain having a hummocky micro-relief. Removal of the organic horizon from such terrain will likely result in rapid development of gullies owing to runoff waters concentrating and flowing in the micro-grooves.

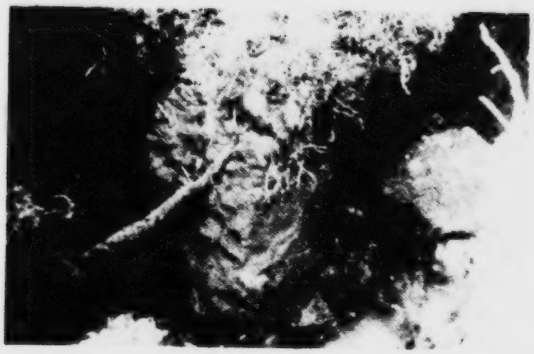
2. Wave erosion

No specific analysis were conducted to measure the susceptibility of soil materials to wave erosion; although, soil dispersibility and structure figure extensively in its evaluation. The dispersion ratio results indicate that upper soil horizons will take a longer time to erode by wave action than unaltered parent materials of similar textural composition. Bnt horizons would be least affected by wave erosion owing to their strong columnar structure. As shown in photo 1, wave action dislodges peds of Bnt horizons from the soil matrix; however, these peds remain intact and sink rather than disperse. Similarly, in areas of hummocky micro-relief, the mound portion of soil hummocks are likely to become dislodged from the soil matrix and sink rather than disperse. This effect was observed at Site 18 and is shown on Photo 2. The photo, taken within 24 hours after excavation, shows a dislodged soil mound which was shored-up to prevent it from slumping into the pit. The contact between the mound and the underlying unaltered material constitutes a slip-surface. In this example, the unaltered material is water-saturated owing to thawing out of the underlying permafrost.

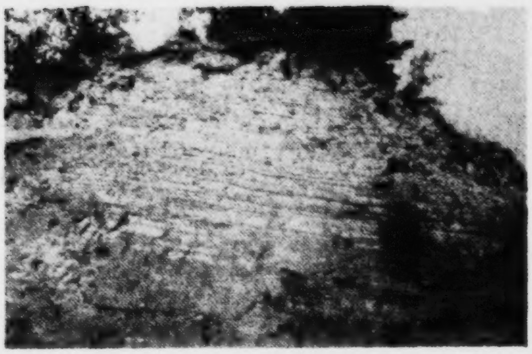
Wave action on unaltered lacustrine materials causes fall-type or flow-type deformation. Flow-type deformations occur in the form of slumping in clay-textured deposits and in the form of slides in dipping, stratified, lacustrine materials. In the latter case, sliding is the result either of saturated conditions of one or more of the strata (beds) or of their liquifaction due to man-made disturbances. Liquifaction of silt-textured material has been measured to occur at a field-moisture content of 18 per cent.

Wave action on flat, stratified lacustrine deposits causes bank-undercutting followed by soil fall. This produces cliff-like shorelines, as illustrated on photos 3 and 4. Mature shorelines in areas of lacustrine deposits will likely be bedrock-controlled. Clay-textured materials on bedrock are expected to attain a characteristic shoreline slope of about 80 per cent (photo 5).

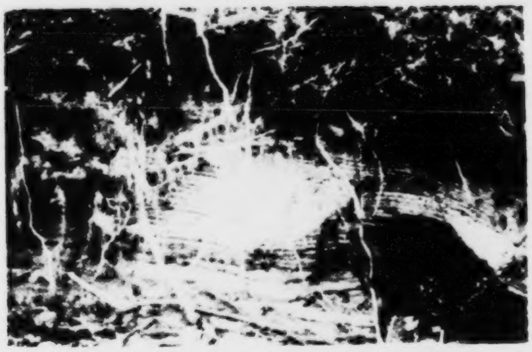
1. Dislodgement of peds from a Bnt horizon resulting from erosion by wave action.



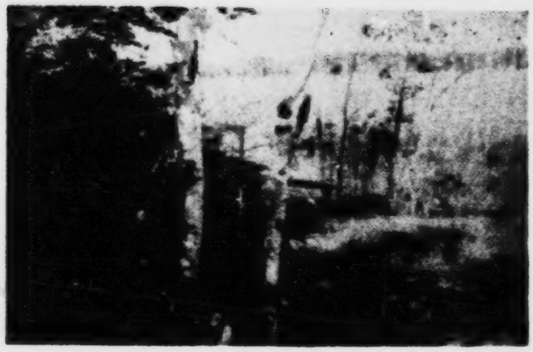
2. Soil mound, shored up to prevent it from slumping into excavation



3. Embankment of stratified lacustrine deposits on island in Harding Lake.



4. Recent shoreline development in stratified lacustrine deposits along Sipiwesk Lake.



5. Exposed bedrock shore and clay-textured lacustrine deposits above the high-water mark.

TABLE X. ESTIMATED PERMEABILITIES OF RELATIVELY UNALTERED MATERIALS

Material	Textural Classification			Permeability (in./hr.)
	CSSC[1]	AASHO[2]	Unified[3]	
Lacustrine	C	A-7-6	CH-MH	0.05
	SiCL,SiC	A-6-7	CL	0.05 - 1.0
	CL	A-4 to A-6	ML-CL	0.6 - 1.0
	SiL	A-4 to A-5	ML or CL	0.6 - 2.0
	L	A-4	ML	0.6 - 2.0
	SL	A-3	ML	1.0 - 4.0
	VFSL	A-2-4	ML	1.0 - 4.0
	VFS	A-3	SW	6.0 - 10.0
	LVFS	A-2	SM	6.0 - 10.0
	FS	A-3	SW	6.0 - 10.0
	S and FGr	A-1	GW-GP	10.0+
Acid Till	SL	A-2 to A-3	ML-SM	2.0 - 6.0
Calc. Till	CL	A-4	ML	0.6 - 1.0
Glacio-Fluvial	S and FGr	A-1	GW-GP	10.0+

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[1] The System of Soil Classification for Canada. 1970. Canada Department of Agriculture. Queen's Printer.

[2] Standard Specifications for Highway Materials and Methods of Sampling and Testing (The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, Designation: M145-149) Part 1, Ed. 8, American Association of State Highway Officials, 1961. Washington, D. C.

[3] The Unified Soil Classification System, Technical Memorandum No. 3-357, Vol. 1, Waterways Exp. Sta., U.S. Corps of Engineers, March, 1953.

B. Permeability

Permeability of a soil as it occurs in place is mainly dependent on its texture, structure, and consistence. The time allotted for this study did not permit permeability measurements of undisturbed soil nor of disturbed materials. Estimates of the undisturbed permeability of relatively unaltered materials are provided in Table X, as based on measurements from elsewhere in the Province. Field permeabilities of less than 2.0 inches per hour will be most frequently encountered in the study area, since lacustrine silt and clay materials predominate.

The permeability estimates listed in Table X will be influenced to a greater or lesser extent by the structure and consistence of the materials. Permeabilities of the unaltered lacustrine deposits will be affected by the thickness of the varves or laminae and their material composition. In this respect, the permeability estimates should be lower than indicated when dealing with stratified lacustrine deposits. The extent of such decreases in the estimated values is dependent on the textural variation between the laminae. Structural changes found in materials affected by soil formation are likely to increase the permeability of the materials; excepting platy structures.

The degree of expression of soil structure in various horizons is reflected, to some extent, by their bulk density measurements (Table IX). Generally speaking, the higher the bulk density value, the more pronounced the horizon structure. The results obtained show that the AB, BA, Bt and Bnt horizons have the highest bulk densities. Bulk density values for texturally-different laminae from stratified lacustrine deposits vary considerably; being unrelated to the pseudo-platy structure which such laminae have in common.

C. Plasticity

The tests for liquid limit and plastic limit measure the effect of water on the consistence of soil. The plastic limit signifies the change from the friable to the plastic consistence. At this point, orientation of particles and their subsequent sliding over each other take place since sufficient water has been added to provide a film around each particle. The liquid limit signifies that moisture content at which the water films become so thick that cohesion is decreased and the soil mass flows under an applied force. The plasticity index represents the amount of water that must be added to a soil system to produce the change from the point where the soil ceases to be friable to that where the soil begins to flow. Soils for which the liquid or plastic limit cannot be determined or for which the plastic limit is equal, to, or higher than, the liquid limit are termed non-plastic.

Results for soil plasticity are presented in Table XI. They show that plasticity increases with the content of smaller particles, being highest for materials classified as clay. Within this textural class, the plasticity index varies from 14.3 to 42.5. The results also show that materials affected by soil formation have a lower plasticity index than their respective, unaltered parent material or C horizon. A liquid limit of as low as 15.7 has been measured for the Ck(a) horizon (i.e. a component bed of the stratified lacustrine parent material) of Site NH 12. This and other results corroborate the field observation and measurement at Site SI 16 of liquifaction taken

TABLE XI. ENGINEERING TEST DATA FOR SOME SOILS OF THE STUDY AREA.

Site #	Horizon	Textural Class[1]	Plasticity			Shrinkage			
			Liquid Limit	Plastic Limit	Index	Satur. (%)	Limit %	Ratio %	Lineal (Dish) %
T3	Ahg	C	30.0	24.9	5.1	36.4	24.0	1.65	3.36
	Ckg1	SiL	21.8	18.2	3.6	28.7	18.0	1.89	3.86
	Ckg2	C	34.9	20.6	14.3	41.7	17.8	1.83	8.87
T4a	Ae	C	57.0	39.2	17.8	71.9	27.0	1.52	12.47
	Bt1	C	58.5	35.4	23.1	63.6	19.6	1.75	15.46
	Bt2	C	60.0	33.8	26.2	69.8	20.7	1.79	16.34
	BC	C	53.5	32.1	21.4	60.7	20.7	1.75	13.56
	C	SiL	39.6	23.4	16.2	47.1	20.0	1.77	10.36
T9	Ae	CL	26.3	17.6	8.7	42.3	16.5	1.80	5.52
	AB	C	37.7	20.8	16.9	39.5	14.9	1.84	8.70
	Bt	SC	31.8	19.6	12.2	33.0	14.6	1.88	7.43
	BC	SL-SCL	22.5	14.3	8.2	25.3	13.3	1.94	4.10
	Cca	L	22.5	16.2	6.3	27.5	15.9	1.84	4.11
	Ck	SL	18.5	13.1	5.4	23.8	14.8	1.92	3.37
T10	Bm	SiL-SiCL	59.3	39.3	20.0	76.5	36.5	1.22	8.11
	BC	SiC	48.8	31.9	16.9	57.2	23.5	1.53	9.44
	Ck1	SiL	25.0	18.7	6.3	35.6	21.8	1.67	3.86
NH6	Ae	C	51.7	30.0	21.7	54.5	23.4	1.50	8.39
	AB	C	50.5	29.9	20.6	63.7	19.7	1.71	14.49
	Bnt1	C	65.4	31.5	33.9	64.9	18.3	1.83	15.35
	Bnt2	C	65.3	32.4	32.9	70.5	18.2	1.81	17.11
	BCk	C	56.0	31.4	24.6	64.1	16.9	1.79	14.87
	Ck1	C	66.7	27.2	39.5	67.0	20.7	1.71	14.73
	Ck2	C	54.9	25.7	29.2	55.9	23.0	1.74	13.70

TABLE XI (continued)

Site #	Horizon	Textural Class[1]	Plasticity			Shrinkage			
			Liquid Limit	Plastic Limit	Index	Satur. (%)	Limit %	Ratio %	Lineal (Dish) %
NH12	Ae	SiCL	39.4	26.3	13.1	49.8	24.3	1.48	6.04
	Bt	C	62.2	29.3	32.9	60.6	14.9	1.96	16.95
	BC	SiC	40.4	22.0	18.4	47.4	20.2	1.76	9.16
	Ck(a)	SiL	15.7	13.0	2.7	24.8	15.9	1.92	1.92
	Ck(b)	SiL	31.7	18.3	13.4	39.2	19.1	1.77	5.30
NH14	Ae	C	68.9	33.3	35.6	67.1	19.6	1.72	16.31
	Bm	C	75.0	32.5	42.5	67.9	13.8	1.89	18.12
	BC	C	53.7	25.2	28.5	55.3	20.4	1.78	14.98
	Ck1	SiC	39.8	22.7	17.1	47.2	22.8	1.71	7.93
	IICk2(a)	LS	N.P.						
	IICk2(b)	L	28.0	17.3	10.7	39.4	25.3	1.62	4.11
NH17	Ae	C	54.9	31.5	23.4	57.4	25.7	1.52	10.41
	AB	C	54.3	27.8	26.5	48.3	17.7	1.79	11.08
	Btnj	C	64.0	27.0	37.0	59.4	16.7	1.89	15.79
	Bt	C	68.1	29.4	38.7	70.6	16.3	1.86	16.55
	Ck1	SiC	48.5	22.8	25.7	52.4	19.2	1.84	11.84
	Ck2	SiL	28.1	14.9	13.2	36.1	18.8	1.81	5.76
	Ck3	SiC	51.1	22.8	28.3	52.0	18.5	1.83	11.33
	Ck4	SiCL	28.8	18.6	10.2	34.3	18.1	1.84	5.56
	Ck5	SiL	25.1	15.4	9.7	28.0	17.1	1.94	4.07
NH19	Ae	SiL	32.0	21.4	10.6	39.3	31.3	1.41	2.17
	AB	SiL	40.0	21.0	19.0	45.1	21.1	1.68	8.47
	Bt	SiCL	50.2	21.9	28.3	46.7	15.9	1.85	11.08
	Ck1	SiL	31.1	19.5	11.6	38.2	24.0	1.66	4.55
	IICk2	SL	N.P.			18.1	21.7	2.06	1.92

TABLE XI (continued)

Site #	Horizon	Textural Class[1]	Plasticity			Shrinkage			
			Liquid Limit	Plastic Limit	Index	Satur. (%)	Limit %	Ratio %	Lineal (Dish) %
NH23	Ae	SiL	26.8	23.2	3.6	40.6	29.3	1.46	3.14
	Bm	SiL	N.P.			26.2	15.9	1.81	2.88
	BC	SiL	N.P.			26.1	17.4	1.87	1.69
	Ck1	SiL	N.P.			26.1	15.9	1.88	2.17
	C2(a)	SiL	N.P.			22.4	17.0	1.86	3.13

[1] The System of Soil Classification for Canada. 1970. Can. Dept. Agric., Queen's Printer.

at a moisture content of less than 20%.

D. Shrinkage

Shrinkage refers to measurement of volume changes with variations in moisture content. The shrinkage limit of a soil signifies that moisture content at which an equilibrium condition of volume change is reached and further reduction in moisture content will not cause a decrease in the volume of the soil mass. The shrinkage ratio of a soil is the ratio between the volume change and the corresponding change in moisture content. It equals the apparent specific gravity of the dried soil. The lineal shrinkage of a soil is the decrease in one dimension, expressed as a percentage of the original dimension of the soil mass, when the moisture content is reduced from a stipulated percentage to the shrinkage limit.

The results in Table XI show that soils classified as clay (C) generally have high shrink-swell potential. Non-plastic soils and those having a small amount of slightly plastic fines have low shrink-swell potential. The results also show that soil B horizons generally have a higher shrink-swell potential than their relatively unaltered C horizon of similar texture.

E. Eutrification Potential

Sodium bicarbonate has been employed to extract the portion of the soil phosphorus that could be correlated with the eutrification of alkaline water upon land flooding.

Results presented in Table IX show that such water may extract considerable quantities of phosphorus. Organic materials and mineral materials with a relatively high organic carbon content have the highest content of bicarbonate-soluble phosphorus. Such mineral materials are mostly from soils having imperfect or poor drainage. The bicarbonate-soluble phosphorus content of organic materials is expected to vary according to composition and degree of decomposition. In this respect, sphagnum peat will likely contain the least amount of bicarbonate-soluble P, followed by sedge peat while forest peat and forest litter should contain the highest amount.

In general, the bicarbonate extractable phosphorus decreases with increase in soil depth. Relatively unaltered soil materials contain the least amounts of extractable phosphorus. The amount extracted from such materials varies according to texture, coarse materials containing a lesser amount than fine-textured materials.

Annex I

A. LAND DISTRICTS OF THE RAT-BURNTWOOD RIVERS AND SOUTHERN INDIAN LAKE PROJECT AREAS

MY Mystery Lake Land District

Characterized by deep lacustrine clay and silt, and glacio-fluvial sand and gravel. Thick to thin organic material overlies the mainly lacustrine mineral deposits in depressions and flat areas with impeded drainage. Some infrequent Precambrian gneissic and granitic bedrock outcrops occur.

The lacustrine clay and silt deposits have a gently undulating to gently rolling topography and are generally thick to very thick over bedrock. These deposits are laminated; the laminae usually being greater than one inch thick. The common soils encountered on these deposits are Gray Luvisols, which may or may not show evidence of cryoturbation, and Low Humic Eluviated Gleysols.

Black spruce will form the climax forest vegetation on most sites. Depending on moisture regime, the groundcover will vary from a thin organic layer of feathermosses, lichen, and forest litter to rather thick layers of organic material derived from feathermosses, sphagnum mosses and forest litter. The present forest vegetation may be completely different from that in the climax stage, owing to disturbances mainly caused by fire. On dry sites jack pine, white birch, and, to some extent, black spruce will form the intermediate forest cover. On more moist sites, trembling aspen will form a major component of the subseral forest cover. In areas with poor drainage, black spruce will form the fire regeneration as well as the climax forest. Along lakes and streams the stable vegetation is often a mixture of black spruce, white spruce, trembling aspen and balsam poplar, the latter especially in areas which are flooded from time to time and are subject to some deposition of alluvial materials.

Permafrost is found in areas which have imperfect or poor drainage and an organic surface layer thick enough to create adequate insulation. The active layer varies in thickness from 18 to 30 inches; but may be locally thicker. Ice content of the permafrost is low.

The glacio-fluvial deposits are undulating to gently rolling in topography. These deposits are generally quite deep; the underlying bedrock having very limited influence on the topography. Degraded Dystric Brunisols are the common soils present with Orthic Regosols occurring in disturbed areas, such as blow-outs.

As a result of fires, jack pine and white birch often form the forest cover. Black spruce may constitute part of the stand mixture and may form the climax forest cover if no disturbances occur. The organic surface layer is generally thin and composed of feathermosses, lichen and forest litter. Because of their textures, these landforms are normally well drained and little or no permafrost is found. Some permafrost is found in those areas that have heavier organic mantles, in which case the permafrost occurs in the organic material.

The low relief organic deposits vary from thick to thin and are usually underlain by lacustrine materials. The moisture regime varies from saturated to rather dry as a result of peat buildup and permafrost. The wet to very wet areas are comprised of sedge peat, sphagnum peat, or mixtures of both. Palsas and peat plateaux are organic landforms, that are raised compared to the surrounding area as a result of peat accumulation and permafrost. A relatively extensive forest cover is found on these landforms, whereas fen-type peat landforms generally lack tree vegetation. The stable forest cover on the palsas and peat plateaux is black spruce with a variable component of white birch. The active layer is about 18 inches thick and the surface is rather dry. The ice content in the frozen peat is high.

Very few lakes occur in this area. Most are pitted lakes in glacio-fluvial material, which are small, fairly deep and have sandy shores. Some small to medium sized lakes occur in the remainder of the area. The shores of the latter and of the rivers consist of clay and bedrock primarily.

PL Paint Lake Land District

Characterized by thick lacustrine clay and silt deposits and thick to thin organic accumulations that overlay lacustrine materials in depressions and flat areas with impeded drainage. Precambrian gneissic and granitic bedrock is infrequently exposed or close to the surface.

The lacustrine areas have a very gently undulating to gently rolling topography and are generally thick to very thick over Precambrian bedrock. These deposits have alternating clay and silt laminae which vary in thickness from location to location but also with depth. The common soils are: Gray Luvisols and Low Humic Eluviated Gleysols.

Permafrost is found in poorly and imperfectly drained areas when a thick organic layer is present. The active layer is about 1 1/2 to 2 feet thick. The permafrost extends into or occurs solely in the mineral soil; the latter situation occurring infrequently in better drained positions.

Black spruce forms the climax forest vegetation on most sites, i.e. moisture conditions ranging from fairly dry to wet. Along lakes and rivers the climax forest is a mixture of white spruce, black spruce, trembling aspen and balsam poplar. The present forest cover is often subseral in nature. On the well drained sites, jack pine and white birch with some black spruce will form the forest cover after fire, while trembling aspen will be subseral on moist sites. On sites with a thick organic overlay the fire regeneration is mainly black spruce.

Extensive areas consist of thick to thin organic accumulations which have low relief. The slight differences in elevation in these peatlands are a result of permafrost and peat accumulation. In the wet and very wet peat areas, which consist of sedge peat and/or sphagnum peat over sedge peat, tree growth is very stunted. Scattered tamarack and some black spruce are the tree species present. On the frozen elevated peat bodies (palsas and peat plateaus), the forest cover can be rather dense and consist mainly of black spruce with some white birch. The peat material consists of sphagnum and forest peat, often over sedge peat.

The large lakes in this district have irregular, mostly bedrock controlled shorelines. These lakes are fairly deep and dotted with bedrock-controlled islands. The smaller lakes are shallow and have rather smooth, peaty and/or clayey shorelines.

HL Hunter Lake Land District

Characterized by thick lacustrine clay and silt deposits, and thick to thin peat overlying lacustrine materials. Precambrian gneissic and granitic bedrock is infrequently exposed throughout the area.

The topography of the lacustrine areas ranges from very gently undulating to gently rolling. The deposits are varved and are generally thick to very thick over bedrock. The common soils are: Gray Luvisols, which usually show evidence of cryoturbation, and Low Humic Eluviated Gleysols.

Black spruce forms the climax forest on most sites. Density and height growth of black spruce as well as groundcover and organic accumulation will vary, depending primarily on moisture regime. The better drained sites have a shallow LFH layer mainly consisting of feathermosses, lichens and forest litter. With increase in moisture supply, the organic layer becomes thicker and eventually becomes a peaty overlay. The present forest cover of many sites differs from the climax one, owing to fire disturbance. On dry sites, jack pine and white birch are the dominant subseral tree vegetation while, on more moist sites, trembling aspen will form a major component of the stand. Wet sites with thick organic layers will have black spruce as forest cover, even after fire, with alder and willow forming an extensive shrub cover.

Suitable sites along lakes and streams have a mixed-forest comprised of black spruce, white spruce, trembling aspen, white birch, and balsam poplar.

Permafrost is found in soils with a thick organic layer. On sites with a very thick organic layer the permafrost occurs in the organic deposit. Their active layer is about 1 1/2 to 2 feet thick and extends into the mineral material. In soils with better drainage the permafrost is found between 2 to 4 feet depth, depending on the thickness of the LFH layer. Fairly dry sites usually lack permafrost.

Very extensive areas are covered by peat. These areas have a low relief with differences in elevation ranging between 2 and 10 feet. The topographic variations are caused by peat accumulation, permafrost, and occasionally by the topography of underlying mineral materials.

The wet to saturated areas consist of sedge peat which may overlay other kinds of peat at greater depths. These areas have little or no forest cover. When present, it consists of some stunted tamarack and/or black spruce. The raised peat landforms -- palsas and peat plateaux -- support a forest vegetation of black spruce and, to some extent, white birch. The organic material is comprised of sphagnum and forest peat which may overlie sedge peat. The ice content of the frozen organic material is high.

The lakes in this district are relatively small and shallow, and have regular shorelines in organic and clay shore materials.

PH Partridge Crop Hill Land District

Characterized by sandy end-morainic and glacio-fluvial deposits, lacustrine clay and silt deposits, and thin to thick organic accumulations. Precambrian gneissic and granitic bedrock occurs frequently at or close to the surface.

The morainic and glacio-fluvial areas are gently undulating to rolling. Parts of these areas are flat, lower slopes often being covered by organic accumulations. Silty materials occur along the edges of the sand deposits, and often have an organic overlay. In general, this silt overlies clay-textured lacustrine material. Most common soils are: Dystric Brunisols on the sandy deposits and Rego Gleysols and Gray Luvisols on the lacustrine materials.

The present forest cover consists of jack pine and white birch. If left undisturbed, black spruce may form part of the forest cover. Lower slopes and flat areas with impeded drainage have a black spruce cover.

Permafrost does not occur in the better drained materials. Some permafrost may be found in moist areas with thick organic accumulations. The wet to very wet conditions that prevail in most of the District have inhibited the development of permafrost.

The lacustrine areas have a very gently undulating to slightly rolling topography. Some steeper relief is found in areas where bedrock affects the topography. The forest vegetation on these landforms is the same as in land districts PL and HL. Permafrost is somewhat less frequent than in the afore-mentioned land districts, even on sites with sufficient organic insulation. The organic peat lands have very low relief. Permafrost is found in palsas and peat plateaux (see PL and HL).

The water bodies in this district are generally small and shallow with regular peat shorelines.

AL Apeganau Lake Land District

Characterized by thick lacustrine clay and silt deposits and thin to thick organic deposits overlying lacustrine material. Precambrian, gneissic and granitic bedrock at or close to the surface occurs in isolated areas.

The lacustrine clay and silt deposits have a very gently undulating to very gently rolling topography and are generally thick to very thick over bedrock. These deposits are laminated with the clay and silt laminae varying in thickness. Common soils encountered are: Gray Luvisols and Low Humic Eluviated Gleysols.

Black spruce generally forms the climax forest vegetation. Most sites are imperfectly drained and have rather thin organic layers overlaying the mineral materials.

Permafrost is found throughout but is not widespread. The active layer is about 2 feet thick.

Extensive thin to thick organic deposits occur which are usually underlain by lacustrine materials. These peatlands have a very low relief. Black spruce cover is found on the raised peat bodies which contain permafrost. The wet peatlands -- collapse scars and fens -- are almost void of tree vegetation, except for scattered, stunted tamarack and black spruce. The ice-content of the permafrost is high.

The bedrock-controlled areas are undulating to rolling and contain frequent bedrock outcrops. The unconsolidated mineral overlay varies from thin to thick as does the organic overlay in depressions. Black spruce forms the climax forest cover but, as a result of fires, the present cover consists often of jack pine, white birch or trembling aspen with black spruce in mixtures or as understory.

Permafrost is found on the lower slopes where a peaty layer has developed. Some permafrost occurs at depth in mineral soils with thin LFH. Ice contents vary from high to low. Two lakes of moderately large size occur in this district. Shorelines are irregular to regular.

Shore materials consist of exposed bedrock, clay and organic materials.

LL Leftrook Lake Land District

Characterized by thick to thin lacustrine clay and silt deposits, some glacio-fluvial sand deposits, extensive thin to thick peat accumulations overlying lacustrine materials, and areas with Precambrian gneissic and granitic bedrock outcrops.

The lacustrine areas have a gently undulating to gently rolling topography and are generally thick over bedrock. These deposits have clay and silt laminae of varying thickness. Common soils are: Gray Luvisols and Low Humic Eluviated Gleysols on the lacustrine materials and Dystric Brunisols on the glacio-fluvial deposits.

Black spruce forms the climax forest vegetation on most sites. As a result of fire, jack pine, white birch and on moist sites, trembling aspen constitute the forest cover, often in mixture with black spruce or with black spruce in the understory. The organic layer varies in thickness from rather thin on the well drained sites to thick or even peaty on the moist and very moist locations.

Permafrost occurs locally in the mineral soils but is more frequently found in the organic accumulations.

Extensive areas are covered by thin to thick, low relief organic deposits. Palsas and peat plateaux normally have a black spruce cover with some white birch as second component. The active layer is about 1 1/2 feet thick and ice content of the permafrost is high. The flat, very wet peatlands do not contain permafrost and have mainly a sedge or sedge/sphagnum vegetation with scattered, stunted tamarack and black spruce.

Bedrock-controlled areas have an undulating to rolling topography. Surface materials consist of exposed bedrock and thin to thick lacustrine and/or organic deposits overlaying the bedrock.

Black spruce forms the climax forest cover. As a result of fires, it is often replaced by or mixed with jack pine and to some extent white birch on the drier sites.

The lakes are relatively small, deep and have irregular shorelines which are mainly bedrock controlled.

WW Wuskwatim Lake Land District

Characterized by thick lacustrine clay and silt, thin to thick organic accumulations overlying lacustrine materials, thin lacustrine and organic deposits underlain by Precambrian bedrock, and exposed bedrock.

The lacustrine areas have a very gently undulating to gently rolling topography, slightly influenced by the configuration of the underlying bedrock. These deposits have silt and clay laminae of varying thickness. Common soils encountered on these deposits: Gray Luvisols and Low Humic Eluviated Gleysols.

Black spruce forms the climax forest vegetation on most sites. Depending on moisture regime, the thickness of the organic layer will vary from a thin LFH layer composed of feathermosses and forest litter to peaty overlays composed of dead and living sphagnum and feathermosses as well as forest litter.

The present vegetation is often in an intermediate, subseral stage. In these stands black spruce often constitutes an important component of the species composition, depending partly on the time lapse since disturbance. Jack pine and white birch generally predominate in subseral forests on dry sites while trembling aspen is dominant on moist locations. Sites with a peaty overlay generally have a black spruce vegetation with alder and willow forming an extensive shrub cover.

Along lakes and rivers white spruce will form part of the species composition as will balsam poplar. Permafrost is not widespread in this area and is confined to those soils which have a peaty overlay.

The low relief organic deposits are thick to thin and are underlain by lacustrine materials.

The very wet organic areas have fen-type vegetation and have little or no tree growth. Stunted tamarack is evenly distributed or, in the case of patterned fens, occurs on the ridges. Some stunted black spruce may be present, particularly along the borders of these units.

The raised peat landforms are the result of peat accumulation, permafrost, and sometimes underlying materials. They support a black spruce forest cover of varying density and height growth. White birch often occurs in association with the black spruce. The active layer is normally 1 1/2 to 2 feet thick and the ice content of the permafrost is high.

Areas consisting of a thin overlay over bedrock or exposed bedrock show slight elevation differences over short distances but, generally speaking, have a weakly broken topography. In depressions organic material has accumulated which may overlay bare bedrock or thin lacustrine deposits. Permafrost is of local extent in these areas.

The main water body of this District is Wuskwatim Lake which has irregular to regular shoreline. Bedrock comprises the dominant shore material with clay and organic materials being of lesser importance.

NH Nelson House Land District

Characterized by Precambrian gneissic and granitic bedrock which is either exposed or covered with a thin overlay of lacustrine and/or organic materials. Thin to thick lacustrine deposits occur in the valleys and on the slopes of the bedrock-controlled terrain. Thin to thick organic deposits have developed in areas with impeded drainage.

The bedrock outcrops have gentle to steep slopes but are rounded or flat at the top. Shallow lacustrine and/or organic deposits overlie the bedrock in depressions and on the gentle slopes. The present vegetation on gently sloping sites is mainly subseral and dominated by jack pine, but black spruce will likely form the climax. White birch is also often found in these areas. On slopes with somewhat thicker mineral deposits trembling aspen can form the intermediate forest cover but will be replaced by black spruce in advanced stages of forest development. Black spruce forms the forest vegetation on organic deposits. Very little permafrost is encountered in the bedrock-controlled areas; when present, it occurs in the organic deposits.

The lacustrine deposits have a gently undulating to rolling topography. In the latter case the relief is bedrock-controlled. Black spruce forms the climax vegetation on most sites, but as result of fire, is often replaced by jack pine, white birch or trembling aspen, depending on moisture regime. Permafrost is more frequently found in these areas, especially in locations where a peaty overlay has developed.

The organic deposits have low relief and overlay lacustrine materials. A forest ocver of black spruce occurs on the raised peat landforms (palsas and peat plateaux). The ice content of the permafrost is high. Collapse scars and fens generally lack tree vegetation, although scattered stunted tamarack and black spruce do occur, in particular, on ridges.

A number of large, deep lakes occur in the district. The shore material of these lakes consists mainly of exposed bedrock.

NL Notigi Lake Land District

Characterized by Precambrian gneissic and granitic bedrock, which is exposed or very close to the surface in most of the area, and lacustrine and peat deposits in valleys and depressions.

The bedrock areas have rather steep slopes with rounded or flat crests. The topography ranges from gently to strongly rolling. Exposed bedrock is usually void of vegetation. Black spruce and jack pine can be found in shallow depressions where unconsolidated materials have accumulated. On the slopes a thick layer of mainly lacustrine materials overlay the bedrock and more and better tree cover is found.

The lacustrine areas have a gently undulating to gently rolling topography which is slightly to moderately controlled by bedrock except in the valleys and plains between the bedrock outcrops. These materials are often overlain by an organic deposit. Black spruce is the most common tree species but trembling aspen, balsam poplar and white spruce are found on suitable sites; the latter two especially in the vicinity of lakes and rivers. Permafrost is found in these mineral soils when drainage and thickness of the organic layer are favourable.

Peat deposits of varying thickness frequently overlay the lacustrine materials. Permafrost is found in the raised peat landforms and has a high ice content.

Small and moderately large lakes are scattered throughout the district. Shore materials consist of bedrock and clay.

RL Rat Lake Land District

Characterized by Precambrian gneissic and granitic bedrock, which is close to or at the surface in the major part of the area, and lacustrine clay and silt deposits and peat deposits overlying lacustrine materials.

The bedrock areas are undulating to moderately rolling; bedrock being frequently exposed. In depressions and on lower slopes the bedrock is covered by thin to thick lacustrine materials which, in turn, are overlain by organic deposits in depressions. The dry sites generally have a subseral jack pine cover with black spruce often occurring as regeneration. In depressions and on slopes the vegetation is mainly a mixture of black spruce, jack pine, white birch and trembling aspen. In poorly to very poorly drained locations the tree cover is stunted black spruce mixed with often tall willow and alder.

Permafrost occurs on the slopes and in depressions, mainly under or in thick organic layers and has a medium to high ice content.

The lacustrine areas have a topography ranging from gently undulating to gently rolling, depending on the degree of control by the underlying bedrock. The forest cover is mainly black spruce, which may be replaced (as the result of fire) by jack pine and white birch on the drier sites and by trembling aspen on fresh to moist locations. Permafrost is found throughout but occurs mainly on sites with a thick LFH or peaty layer. Ice content is moderate to high.

The organic areas have a low relief. The very wet peat areas have a sedge vegetation. A forest cover of black spruce, mixed with white birch is found on the raised peat landforms. The ice content of the permafrost in peat palsas and peat plateaux is high.

Many lakes occur in this district which vary in size from small to moderately large, are deep, and contain many rocky islands. Shore materials are mainly bedrock, clay or organic in nature.

IL Issett Lake Land District

Characterized by extensive, thick organic deposits, thick lacustrine clay and silt deposits, and infrequent Precambrian gneissic and granitic bedrock outcrops.

The extensive peat areas have a low relief. The peat is generally thicker than 9 feet, saturated, and without permafrost, particularly along the Rat River. Palsas and Peat plateaux are quite common in this District and are often associated with variations in relief of the underlying materials. These landforms can support fairly good black spruce forests which may be mixed with white birch and, to some extent, trembling aspen.

The lacustrine areas generally have a gently undulating topography. Black spruce and, to a lesser extent, white spruce and trembling aspen form the forest vegetation. Permafrost is common in the mineral soil and raised clay landforms with slumping edges are frequently encountered.

The ice content of the permafrost varies from moderate in the mineral materials to high in the peat deposits.

The shore materials of the water bodies consist of exposed bedrock, and clay and organic materials. The Rat River proper mainly has organic shore materials.

SB South Bay Land District

Characterized by extensive Precambrian gneissic and granitic bedrock areas which are overlain by lacustrine and organic deposits, but frequently show exposed bedrock. The remainder consist of thin to thick lacustrine clay and silt deposits, often overlain by thin to thick peat, and of infrequent glacio-fluvial deposits consisting of sand and gravel.

The strongly bedrock-controlled areas have a topography varying from undulating to rolling. Most of the area has a climax black spruce forest vegetation but a subseral cover of jack pine mixed with white birch occurs in part of the area. Trembling aspen occurs on favourable sites, reaching its northern limit in this district. Permafrost is found in the thin to thick mineral and organic deposits which may overlay the bedrock.

The lacustrine clay and silt areas have a gently undulating to gently rolling topography. The configuration of the bedrock is often reflected in the topography even when the deposits are relatively thick. Black spruce forms the climax forest cover but subseral jack pine and white birch often occur on the better drained sites. White spruce occurs mixed with black spruce on favourable sites along the shorelines of lakes.

Permafrost is widespread on moist to fresh sites and even occurs on some of the drier sites. Ice content is moderate.

Common soils are: Cryic Gray Luvisols and Cryic Low Humic Eluviated Gleysols.

The organic areas have a low relief and frequently contain permafrost landforms (palsas and peat plateaux). Black spruce mixed with white birch forms the dominant forest cover. Fens and collapse scars occur frequently. They have sedge or sphagnum vegetation with few, if any, trees.

The present vegetation on the glacio-fluvial sand and gravel deposits consists mainly of jack pine but is often mixed with black spruce or has black spruce in the understory.

Common soils are: Degraded Dystric Brunisols with minor amounts of Orthic Regosols.

Permafrost is found in more moist locations where organic material has accumulated.

Lakes vary in size from small to very large (Southern Indian Lake) and are generally deep. The shorelines are irregular and have mainly exposed bedrock and sandy shores.

LP Long Point Land District

Characterized by extensive lacustrine clay and silt deposits over Precambrian gneissic and granitic bedrock, and thick to thin organic deposits over lacustrine materials.

The topography of the lacustrine plains varies from gently undulating to gently rolling, reflecting the configuration of the underlying bedrock which is frequently exposed throughout the area.

Common soils are: Cryic Gray Luvisols and Cryic Low Humic Eluviated Gleysols.

The climax forest cover is composed of black spruce which, as a result of fire, may be replaced on drier sites by jack pine and white birch.

Permafrost is widespread throughout the district occurring in dry or moist locations and having a moderate ice content. The glacio-fluvial deposits present in this district often have an intermediate vegetation of jack pine and white birch in mixture with black spruce.

Organic deposits occur in the depressional areas and comprise mixtures of palsas, peat plateaux, collapse scars, and small fens. Permafrost with high ice content is of widespread occurrence.

The lakes range in size from small to very large (Southern Indian Lake) with irregular, bedrock-controlled shorelines. Sandy beaches occur throughout the area.

KH Kame Hills Land District

Characterized by glacio-fluvial deposits, end-morainic and ground-morainic deposits, lacustrine clay and silt deposits, and thick to thin peat accumulations overlying these materials. Precambrian bedrock is infrequently exposed throughout the area.

The topography of the lacustrine terrain is gently undulating to gently rolling, often reflecting the configuration of the underlying bedrock.

Common soils are: Cryic Low Humic Eluviated Gleysols and Cryic Gray Luvisols.

Black spruce forms the climax vegetation on all sites but may be replaced temporarily by jack pine and white birch after disturbance due to fire. Permafrost is encountered throughout this District. The active layer is generally between 1 to 1 1/2 feet thick and the ice content is generally high.

The glacio-fluvial deposits are sandy to gravelly in texture. They often support a subseral jack pine and white birch forest cover although black spruce is frequently found in mixture or as understory. The topography is sometimes rough but mostly rolling. The end- and ground-morainic deposits vary from clay to sandy till and have a forest cover ranging from black spruce to jack pine, depending on drainage and fire history. Permafrost is found frequently in these areas but the ice content varies with the permeability of the material.

Organic deposits overlay the mineral materials in depressions or in areas with imperfect drainage. They consist mainly of palsas and peat plateaux; although, collapse scars are frequent. Ice content of the permafrost is high. Forest cover on the permafrost peat landforms consists of open to fairly closed black spruce with some white birch.

Lakes vary from small to large with irregular to regular shorelines developed in bedrock, clay, organic and sand materials. Sandy beaches occur extensively in this District. The lakes are deep to shallow.

B. LAND DISTRICTS AND LANDSCAPE UNITS OF THE OUTLET LAKES PROJECT AREA

1. General Description of The Outlet Lakes Area

The Outlet Lakes study area covers approximately 4,000 square miles. It is located immediately North of Lake Winnipeg, between latitudes 53° and 55° N and between longitudes 97° and 99° W.

The population of the area comprises about 4,400 people, most of which make their home in the settlements of Cross Lake and Norway House-Rossville. Fishing and hunting are the mainstays of the local economy.

Access to the area is strictly by air or water, although a secondary road leading from highway 391 to the Jenpeg hydro development site was recently completed. As yet, this road does not provide land access to the aforementioned settlements, except during the winter months.

Climate

The climate of the area is cold continental, characterized by a relatively short, cool growing season and moderate precipitation. The mean annual temperature is 28.9° F, as determined from the meteorological records of two stations, Norway House and Wabowden. The average length of the frost-free period[1] is 87 days. The approximate length of the vegetative season -- representing the time period in which the average daily temperature is above 42°F -- is about 160 days, extending from the middle of April to late September.

The average annual precipitation is about 17 inches; approximately one-third of it is in the form of snow or sleet. July is the wettest month of the growing season and May the driest.

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[1] Number of days from last frost in spring to first frost in fall.

Physiography

The term "physiography" is taken to describe the physical features of the land according to its formative history, structure being the primary environmental control in such a classification. Physiographic divisions and provinces are normally delineated on the basis of the constructive geological forces or prevailing structure, while lower levels of classification are based on the destructive forces that produced the land form.

The study area comprises portions of two physiographic provinces, namely the Manitoba Lowlands province of the Interior Plains physiographic division and the Superior province of the Canadian Shield division. The contact between the Manitoba Lowlands and the Superior province is located in the southwestern portion of the map area.

The Manitoba Lowlands portion of the study area is underlain by Ordovician dolomite or dolomitic limestone, occurring in flat beds that dip gently to the south. It occupies about one tenth of the Outlet Lakes study area and has a nearly level to gently undulating topography[1]. The Superior portion of the map area is underlain by granitic bedrock except for a small area of gneissic bedrock around the settlement of Cross Lake. Granitic bedrock generally forms lower and more rounded slopes than gneissic bedrock; although, the slope frequency is high in both cases. The southern half of the Superior portion of the study area is nearly level to undulating while the northern half is characterized by the configuration of the bedrock. Numerous relatively shallow small lakes occur in this part of the

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[1] Terminology according to that outlined in The System of Soil Classification for Canada. 1970, Canada Department of Agriculture, Ottawa.

Superior province.

Surficial Materials

The entire area was glaciated during the Pleistocene epoch. An overall positive slope of the land in front of the glacier ensured the continued presence of a proglacial lake of varying extent, known as Glacial Lake Agassiz. In time, as the lake found lower outlets, the land surface gradually became exposed and organic materials began to accumulate in depressions.

Glacial landforms in the study area include ground moraine, two end moraines, and numerous esker-kame complexes. All these landforms have been modified and subdued, to a greater or lesser extent, owing to their submersion in Glacial Lake Agassiz and, subsequently, to processes of erosion and organic deposition. As a consequence, these landforms, in particular the morainal ones, are often difficult to delineate or observe.

The till material of the morainal landforms is composed dominantly of highly calcareous clay. It consists of overridden lacustrine clay, owing to a readvance of glacier ice across Lake Agassiz sediments, and contains relatively few stones and boulders. An exception to this occurs at the eastern edge of the map area where the till of the "Sipiwesk" end moraine is composed mainly of boulders.

The lake-modified, glacio-fluvial deposits are of local occurrence and tend to be aligned in a northeast to southwest direction. They are composed of weakly calcareous sand, gravel, and cobbles; being best sorted at their southern-most extreme. In addition, most glacio-fluvial deposits in the map area show evidence of sorting due to wave action along their eastern flank.

Unmodified Lake Agassiz sediments are the dominant deposit of the study area. The lacustrine sediments are primarily clay in texture and are highly calcareous. The surface sediments are homogeneous and sparingly stony. They are often underlain by varved clays which may also contain a few rafted stones. Laminated lacustrine deposits are present in small pockets at higher elevations.

Other locally significant Lake Agassiz sediments are the beaches. Their occurrence tends to be restricted to the crest of the two end moraines. They consist of very highly calcareous silt and moderately calcareous sand.

Organic deposits are very prominent in the map area. They are the result of vegetative debris accumulating in poorly drained locations. These deposits occur throughout the map area, being dominant in the southern portion. Permafrost is of local occurrence primarily in fibrous deposits, where it is encountered within two feet of the surface.

Soils

The soils of the study area have developed under boreal forests in moderately cool climate with or without permafrost. These environmental conditions imply that pedogenic processes in mineral soils progress at a relatively slow rate; owing to low order chemical weathering as well as mobilization and transformation of constituents. Organic soils, on the other hand, develop at a fast rate under the prevailing climatic conditions.

Soils belonging to the Organic Soil Order[1] are well represented in the Outlet Lakes map area. The mineral soils present belong primarily to the Luvisolic, the Brunisolic, and the Gleysolic Orders. The development and nature of the major soil profiles in the study area is discussed briefly below.

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[1] Terminology according to The System of Soil Classification for Canada. Canada Department of Agriculture, Ottawa, 1970.

Gray Luvisol soils have developed under forest vegetation on parent material that is mildly to moderately alkaline in reaction. These soils are characterized by an eluvial (Ae) horizon and illuvial, textural B horizons in which silicate clay is the main accumulation product. Under virgin conditions, the soils have organic (L-H) surface horizons. Imperfectly and well-drained soils belonging to this Soil Great Group occur predominantly on the till and the lacustrine deposits of the study area.

Dystric Brunisol soils have developed under forest vegetation on neutral to mildly alkaline, coarse-textured parent materials. They are characterized by organic (L-H) surface horizons, a weakly expressed eluvial (Aej) horizon and weakly expressed illuvial Bm horizons in which sesquioxides are the main accumulation product. These soils are primarily associated with the modified glacio-fluvial deposits. Some Eutric Brunisols occur within the study area. Such soils have similar profile expressions as the afore-mentioned Dystric Brunisols, but their Bm horizons consists of weak illuvial concentrations of silicate clay, if any. They have developed on mildly to moderately alkaline parent materials and, in the study area, tend to be associated with beach deposits.

Regosolic soils are well- and imperfectly drained soils which lack or have very weakly expressed horizon development. In the study area they have organic (L-H) surface horizons under virgin conditions.

They are of limited extent and are associated with certain extremely calcareous lacustrine deposits. In addition, the recent dredge-spoil deposits would be classified as Regosolic soil.

Gleysolic soils have developed under hydrophytic vegetation and are saturated with water and under reducing conditions continuously or during some period of the year. They may have organic surface horizons (OF, OM, OH) of fibric moss or mixed peat and may have A and B horizons. As a result of the reducing conditions, their mineral matrix colours are of low chroma which may contain distinct or prominent mottles of high chroma. These soils are prominent in the study area, having developed on all the geological deposits present.

Organic soils are accumulations of organic residues which are saturated for most of the year. They consist mainly of three kinds of organic material: forest peat, *Sphagnum* moss peat, and herbaceous peat.

A minor portion of the Gleysolic soils and a large proportion of the Organic soils of the study area contain permafrost. These Cryic soils are characterized by the presence of fibrous *Sphagnum* moss or moderately decomposed forest peat. The upper limit of the permafrost is within two feet from the land surface and, according to Brown (1965)[1], its thickness ranges from one foot at the southern limit of the study area to more than 20 feet in the northern areas. They generally form domes or palsas which may be elevated up to ten feet above the surrounding land surface. Such palsas develop when accumulating peat and living vegetation provide sufficient insulation for the frozen layer to increase in volume. As the thickness of the frozen layer, and thus the height of the palsa, increases, an unstable situation arises: the surface moss layer cracks and the sides slump. This partial destruction of the insulative cover changes the energy balance, causing the frozen layer to melt, in part or completely, with concurrent collapse of the palsa.

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[1] Brown, R.J.E. 1965. Permafrost investigations in Saskatchewan and Manitoba. N.R.C., Div. Bldg. Research, Tech. Pap. No. 193, Ottawa.

Vegetation

The atmospheric and soil conditions surrounding and available to vegetation in the study area impose severe restrictions on plant growth and species composition. In addition, these habitat or, in the case of trees, site conditions change rapidly over relatively short distances. Nevertheless, the site is more concrete, more stable, and more readily defined than the vegetation that occupies it. Consequently, the site constitutes a better basis for the evaluation of forest communities than do the trees and other plants. Selection of one or more environmental parameters that influence vegetation and vary from one locality to the next constitute the basis of site classifications. Perhaps the most significant of these variables is the water regime; although soil penetrability and nutrient regime, as well as micro-climatic conditions, cannot be discounted.

In the study area, trends in species composition and, to a lesser extent, growth rate are noticeable when stands of trees are grouped according to site-type based on water regime. On very wet sites black spruce is the only tree of consequence; although larch may occur. Aspen and balsam poplar enter on wet sites but are usually succeeded by black spruce. Jack pine occurs in early successional stages following fire on moist sites but is soon replaced by hardwoods and/or black spruce. White spruce may also occur following the hardwoods or associated with black spruce. On fresh sites the early successional stages are dominated by jack pine and aspen but eventually these are replaced in most instances by black spruce and various admixtures of white spruce. Jack pine is dominant on dry sites initially but is replaced by black spruce.

The greatest proportion of the study area is composed of sites on the wet end of the moisture scale. In some parts of this area, highly calcareous conditions undoubtedly affect the growth of trees. The portion of the study area, composed of the better-drained sites, is very complex, owing to rapid changes in moisture regime over relatively very short distances. Here, the proximity to bedrock and the compacted nature of the lacustrine clay material are expected to affect the growth of trees. In addition, the presence of relatively large water bodies throughout the study area should influence tree growth; although in a favourable manner. Detailed studies would be necessary to determine the magnitude of the effect of these various conditions.

The regional climate favours the growth of frost-hardy evergreen species. Black spruce would dominate the vegetation on all sites within the region if all the disruptive forces were omitted. Jack pine would disappear from most sites after the first generation, except in open stands where it would persist for longer periods. The hardwood species, primarily aspen and balsam poplar, would persist until the spruce formed a closed canopy, as they cannot reproduce under dense spruce stands. White spruce and balsam fir, being secondary invaders, can reproduce under a closed canopy. Its performance would be influenced favourably by the presence of the large bodies of water.

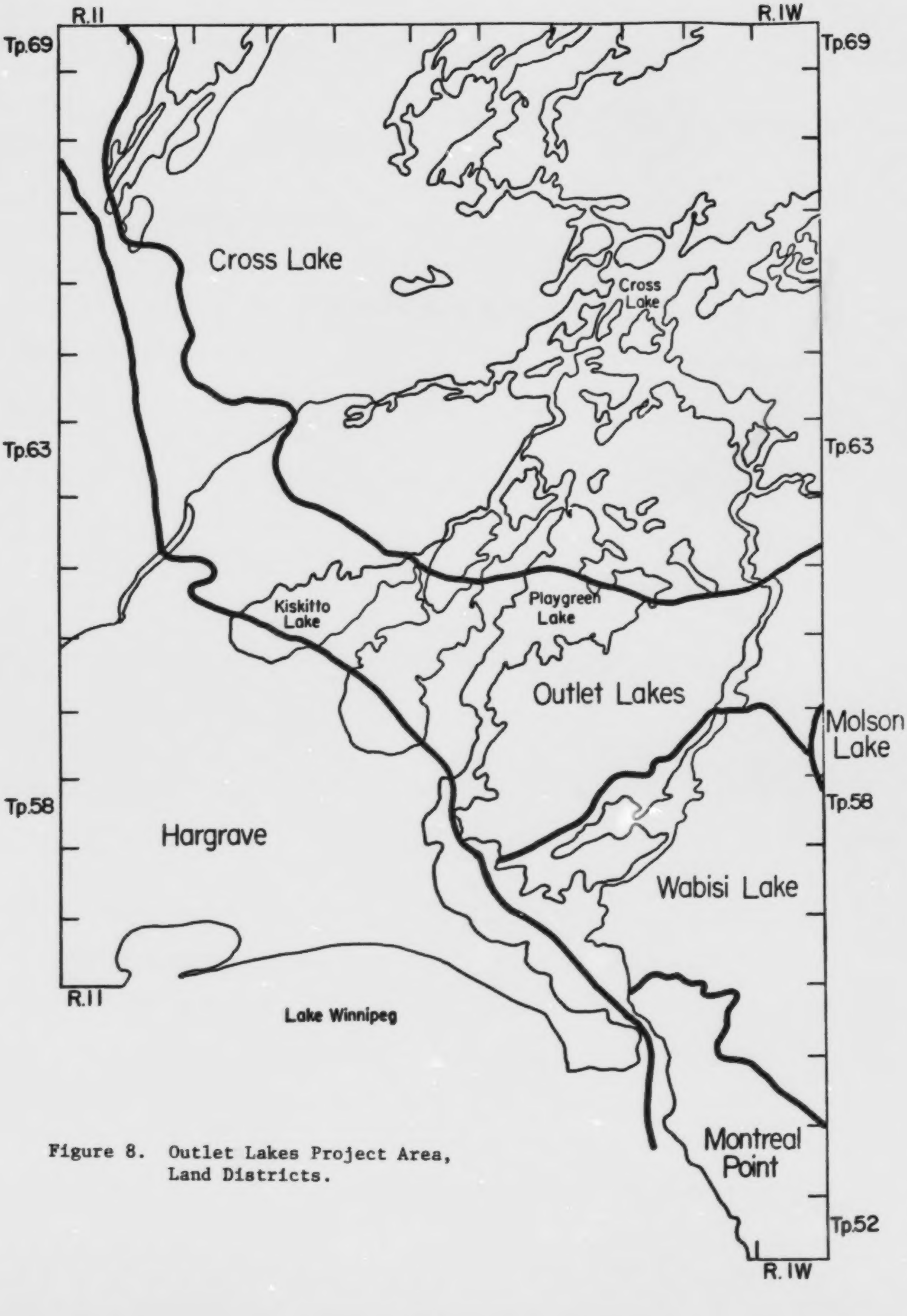
R.11
R.1W
Tp.69
Tp.69
Cross Lake
Cross Lake
Tp.63
Tp.63
Kiskitto Lake
Playgreen Lake
Outlet Lakes
Molson Lake
Tp.58
Tp.58
Hargrave
Wabisi Lake
R.11
Lake Winnipeg
Montreal Point
Tp.52
R.1W

Figure 8. Outlet Lakes Project Area, Land Districts.

Abrupt changes in the environment as brought about by fires and lumbering also have significant effects on the vegetation of the area. The most prominent effect is that on successional stages. In addition, the nutrient regime is affected to a greater or lesser extent, depending on the intervals and durations of the disruptive forces. Generally speaking, fire promotes jack pine and lumbering promotes hardwood species in the early successional stages.

2. Land Districts

Land Districts are defined as areas of land within Land Regions characterized by a distinctive pattern of relief, geology, geomorphology, and associated vegetation (Lacate, 1969).

The following Land Districts were recognized in the study area:

1. Hargrave Land District: characterized by low relief peat plains with few, low relief, lacustrine and modified glacio-fluvial outcrops. A nearly continuous layer of lacustrine clay occurs underneath the peat material. In a large proportion of the area, the lacustrine clay is underlain, in turn, by fine-textured morainal till.
2. Outlet Lakes Land District: characterized by low relief peat plains with isolated Precambrian granitic bedrock outcrops and trains of modified glacio-fluvial deposits. Lacustrine clays occur beneath the peat accumulations.
3. Cross Lake Land District: characterized by undulating to gently rolling topography, controlled by Precambrian gneissic or granitic bedrock. The area is covered by lacustrine clay, underlain in places by fine-textured morainal till, and contains numerous bedrock outcrops. Peat plains occur in the depressions.

4. Wabisi Lake Land District: characterized by undulating to rolling topography, controlled by peat plains and Precambrian granitic bedrock outcrops with isolated occurrences of modified, glaciofluvial deposits. The peat plains are generally underlain by lacustrine clay.
5. Montreal Point Land District: characterized by low relief peat plains with isolated Precambrian granitic rock outcrops. A nearly continuous layer of lacustrine clay is present beneath the peat material, overlying fine-textured morainal till in part of the area.
6. Molson Lake Land District: characterized by rolling topography, controlled by Precambrian bedrock. The area is covered by discontinuous lacustrine clay and some cobbly morainal till. Bedrock outcrops are numerous. Peat plains occur in the depression.

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[1] Lacate, D.S. 1969. Guidelines for bio-physical land classification (Progress Report). Can. Dept. For. and Rural Dev., 46 pp.

[2] Zoltai, S.C., E.T. Oswald, and C. Tarnocai. 1969. Land classification for land evaluation: Cormorant Lake Pilot Project. Can. Dept. For. and Rural Dev., Inf. Rep. MS-X-20, 31 pp.

3. LANDSCAPE UNITS OF THE OUTLET LAKES PROJECT AREA

Landscape Unit 01 (385 sq. mi.)

Very weakly broken area of peat plains underlain by lacustrine clay and thick clay till. Natural drainage of water on the land surface is in a northeasterly direction, excepting areas immediately adjacent to water bodies where it drains to the south.

Land systems comprising the land portion of this landscape unit are: SBx; Fk; FSk; Sk; SF; BxF; FBx; S; BkF; BkS; FS; BxS; F; Bz; 41; BkS-41.

Water occupies 44 per cent of the area, all of which constitutes a part of Lake Winnipeg. The shorelines along this portion of Lake Winnipeg are regular, with an abrupt, steep embankment of over 30 feet in elevation. Shore materials consist of clay till overlain by organic material, either of which may or may not contain permafrost. These materials are subjected to active wave erosion as evidenced from slumping features on the embankment.

Landscape Unit 02 (425 sq. mi.)

Very weakly broken area of peat plains, lacustrine clay and modified glacio-fluvial deposits, underlain by lacustrine clay and deep clay till. Natural drainage of land-surface waters is in a northeasterly direction.

Land systems composing the land portion of this landscape unit area are: BxF-(49); 49-T; BxS; S; BxS-41; 41; BxF; FS; SF; F; BkF; SBx; 41-F; BkS; BkS-1; BkS-4; SBx-4; Sk.

Lakes or portions thereof occupy 30 per cent of the area. Lakes of various size classes occupy the following proportion of the landscape unit:

Large lakes:	15 %
Moderately large lakes:	13 %
Relatively small lakes:	2 %

The moderately large and large lakes constitute but portions of large- to very large-size lakes (Playgreen Lake, Kiskittogisu and Kiskitto Lake). All lakes are moderately deep and have regular shorelines. The shore material is mainly peat, but clay and sandy shores do occur locally.

Landscape Unit 03 (55 sq. mi.)

Very weakly broken area of peat plains and beach deposits underlain by lacustrine clay and thick clay till. The moisture regime of the beach deposits is moist to fresh, except in the most southern portion of the landscape unit where it is wet. Surface waters drain mainly in a southwesterly direction.

Land systems composing the land portion of the landscape unit are: FSk; T; SBx; F; SBz.

The portion of this landscape unit area that is situated within the boundaries of the Outlet Lakes study area does not contain any lakes.

Landscape Unit 04 (73 sq. mi.)

Very weakly to weakly broken area of peat and lacustrine plains. The moisture regime of the lacustrine deposits is fresh when the deposits occur adjacent to stream channels and lakes, but tends to be moist to wet when the deposit is located within the peat plains. Major streams flow in a northeasterly direction; minor streams and other surface waters drain either in an easterly or westerly direction.

Land systems composing the land portion of the landscape unit are: TkS; 89-T; BkS; 49-T; 80-T; 79-T; BxF; BkT-49.

Lakes cover 5 per cent of the landscape unit area situated within the boundaries of the Outlet Lakes study area. These lakes are relatively small in size within the unit area, and constitute a portion of a moderately large lake (Hill Lake).

The lakes are moderately deep and have somewhat irregular shorelines. The shore material consists mainly of lacustrine silt and clay.

Landscape Unit 05 (66 sq. mi.)

Very weakly broken area of peat plains interspersed with bedrock-controlled outcrops. These outcrops consist of exposed bedrock, laminated lacustrine deposits and lacustrine clay materials. The peat plains are underlain chiefly by lacustrine clay. Minor streams and other surface waters drain in an easterly direction.

The land portion of this landscape unit area comprises the following land systems: Fk-39; 39; BkS.

Water bodies occupy 54 per cent of the area. The greater part of these water bodies constitute a portion of a large-size lake (Kiskitto Lake). The various size classes of the water bodies occupy the following proportion of the landscape unit.

Moderately large lake:	53 %
Small lake:	1 %

The moderately large water bodies are moderately deep to deep and have somewhat irregular shorelines; whereas the small lakes are shallow with regular shorelines. The shore material is mainly organic, with minor inclusions of exposed bedrock and laminated lacustrine deposits overlying bedrock. The small lakes are without open outlets.

Landscape Unit 06 (80 sq. mi.)

Weakly broken area of peat plains, and sand-textured water-modified, glacio-fluvial deposits, interspersed with bedrock-controlled outcrops. The peat plains and glacio-fluvial deposits are underlain primarily by lacustrine clay. Peat plains adjacent to the glacio-fluvial deposits tend to be underlain by a thin mantle of sand over lacustrine clay. Natural drainage is mainly in a westerly direction.

Land systems composing the land portion of this landscape unit are: BxF-39; BxF; S; 41; 39; BkF; BkT-49; 49-S; BxF-(29).

Water bodies cover 35 per cent of the area. They constitute portions of large-size lakes (Kiskitto Lake, Kiskittogisu Lake, and Playgreen Lake), and contain infrequent rock outcrops. The various size classes of the water bodies occupy the following proportion of the landscape unit:

Moderately large lake:	31 %
Relatively small lake:	3 %
Small lake:	1 %

The water bodies are moderately deep to deep and have somewhat irregular shorelines. Organic material with minor inclusions of exposed bedrock and sand comprise the shoreline material.

Landscape Unit 07 (100 sq. mi.)

Very weakly to weakly broken area of peat plains, underlain by lacustrine deposits, and interspersed with bedrock-controlled outcrops and sand-textured, water-modified, glacio-fluvial deposits. The bedrock-controlled outcrops are composed of exposed bedrock, laminated lacustrine deposits and lacustrine clay. The laminated lacustrine deposits consist chiefly of silt- and sand-size materials, and include beach deposits. Natural drainage of the land is mainly in a southwesterly direction.

Land systems composing the land portion of this landscape unit are: SF-(49); F-(29); BkF; 41; F.

Water bodies cover 20 per cent of the area. The greater part of these water bodies constitute a portion of a large-size lake (Playgreen Lake), and contain infrequent rock outcrops. The various size classes of the water bodies occupy the following proportion of the landscape unit:

Moderately large lake:	17 %
Relatively small lake:	3 %

The moderately large lakes are moderately deep to deep and have somewhat irregular shorelines. Shore materials consist dominantly of organic material with minor inclusions of sand, clay, and exposed bedrock. The relatively small- and small lakes are shallw to moderately deep and have regular to somewhat irregular shorelines. The shore material is mainly organic; rock outcrops being of minor importance.

Landscape Unit 08 (85 sq. mi.)

Very weakly broken area of dominantly fibric peat plains and rock outcrops. The peat plains are underlain by lacustrine clay, which also covers the sides of the rock outcrops. Drainage is in a southerly direction.

The land portion of this landscape unit area comprises the following land systems: TS-39; FS-19.

Water bodies occupy 70 per cent of the area and belong to the moderately large size class. These water bodies constitute a portion of a large-size lake (Playgreen Lake).

The water bodies are deep and have irregular shorelines. Shore materials are mainly exposed bedrock and organic material.

Landscape Unit 09 (135 sq. mi.)

Weakly broken area of sand-textured, water-modified, glacio-fluvial material and peat plains with infrequent bedrock-controlled outcrops. The peat- and glacio-fluvial deposits are underlain mainly by lacustrine clay or, less frequently, bedrock. The peat plains immediately adjacent to the glacio-fluvial deposits tend to have a thin mantle of sand on top of the lacustrine clay. Drainage of surface waters is mainly in a southeasterly direction, a minor portion of the area draining towards the southwest.

Land systems composing the land portion of this landscape unit are: BkS; SBx; 41; FSk; SkF; SF; BkT; BxS; BxS-(29); FSk-19; BkS-50.

Water bodies cover 11 per cent of the area. The various size classes of the water bodies occupy the following proportion of the landscape unit:

Relatively small lake:	7 %
Small lake:	4 %

The water bodies are moderately deep and have somewhat irregular shorelines. Shore materials are mainly sand and peat, with minor inclusions of exposed bedrock.

Landscape Unit 10 (50 sq. mi.)

Very weakly broken area of peat plains and sand-textured, water-modified, glacio-fluvial deposits, infrequently interspersed with bedrock-controlled outcrops. The peat plains and glacio-fluvial deposits are underlain mainly by lacustrine clay and, less frequently, bedrock outcrops. The land portion drains in a southwesterly direction.

Land systems composing the land portion of this landscape unit are: TS-29; 43; F-10; ST-39; Sk-(10).

Water bodies cover 18 per cent of the area, all of which constitute a portion of a large-size lake (Playgreen Lake).

The water bodies are deep and have irregular shorelines. Shore materials are mainly exposed bedrock and organic material, with minor inclusions of sand and clay.

Landscape Unit 11 (130 sq. mi.)

Very weakly broken area of peat plains with isolated rock outcrops. The peat plains are underlain mainly by lacustrine clay; clay till and bedrock occurring less frequently. Drainage of the land portion is mainly in a southerly direction.

The land portion of this landscape unit area comprises the following land systems: SBk-49; BkS; F-(10); Bz; BxS-(4); SF-(10).

Water bodies occupy 23 per cent of the area and are moderately large in size. These water bodies constitute a portion of a very large-size lake (Lake Winnipeg).

The water bodies are moderately deep to deep and have somewhat irregular shorelines. Shore materials include sand, organic matter, and exposed bedrock.

Landscape Unit 12 (60 sq. Mi.)

Very weakly broken area of peat plains with exposed and submerged beach ridges underlain by lacustrine clay and clay till. Natural drainage of the land portion is in a south to southwesterly direction.

The land portion of this landscape unit area comprises the following land systems: BkS; Bz.

Water bodies occupy 60 per cent of the area and are of moderately large size. These water bodies constitute a portion of a very large-size lake (Lake Winnipeg).

The water bodies are moderately deep to deep and have somewhat irregular shorelines. The shore material consists dominantly of sand with minor inclusions of exposed bedrock. An abrupt steep embankment of clay till overlain by organic material may be present in areas where the shore material is bedrock overlain by clay till.

Landscape Unit 13 (80 sq. mi.)

Very weakly broken area of peat plains and bedrock-controlled outcrops. The peat plains are mainly underlain by lacustrine clay. This material also coats the sides of the bedrock-controlled outcrops. A major stream -- the Gunisao River -- flows in a northwesterly direction; other surface water drainage being approximately perpendicular to this direction.

Land systems composing the land portion of the landscape unit are: FS-19; SF-(10); 19-S; FS-10; ST-20, S-10.

Lakes cover 15 per cent of the landscape unit area situated within the boundaries of the Outlet Lakes study area. Lakes of relatively small size occupy 15 % of this portion of the landscape unit.

The lakes have regular to somewhat irregular shorelines and are shallow to moderately deep. Organic matter is the main shore material, exposed bedrock being of infrequent occurrence. The lakes are without open outlets, draining through bogs.

Landscape Unit 14 (90 sq. mi.)

Weakly to moderately broken area of peat plains, glacio-fluvial materials, and bedrock-controlled out crops. The coarse-textured, water-modified, glacio-fluvial material is underlain chiefly by bedrock. The bedrock-controlled outcrops are composed mainly of exposed bedrock, having deposits of lacustrine clay on their lower sides. The peat plains are mainly underlain by lacustrine clay, which tends to be covered with a thin mantle of sand immediately adjacent to the ice-contact deposits. Natural land drainage is mainly in a westerly direction, whereas the major stream of the landscape unit area flows towards the northwest.

Land systems composing the land portion of this landscape unit are: 41; SF-(10); Sk-59; 59-S; TS-79; FS-24; 29-TS; TS-29.

Lakes cover 12 per cent of the area. Lakes of various size classes occupy the following proportion of the landscape unit:

Relatively small lakes:	10 %
Small lakes:	2 %

The lakes have regular to somewhat irregular shorelines and are shallow. Shore material is mainly organic matter with infrequent exposed bedrock. The lakes are without open outlets, draining through bogs.

. Landscape Unit 15 (235 sq. mi.)

Moderately broken area of bedrock-controlled outcrops and peat plains. The bedrock-controlled outcrops consist of exposed bedrock and lacustrine clay overlying bedrock. Lacustrine clay generally underlies the peat plains. Natural drainage of the land portion of this landscape unit is in a southwesterly direction.

Land systems composing the land portion of this landscape unit are: TS-79; F-(19); 79-S; SF-19; TS-29; 79-TS; 59-SF; 69-S; FS-69; FS-19; FS-(10); 59-S.

Water bodies cover 27 per cent of the area. Lakes of various size classes occupy the following proportion of the landscape unit:

Moderately large lake:	21 % (Little Playgreen Lake)
Relatively small lake:	4 %
Small lake:	2 %

The moderately large lakes have irregular shorelines and are moderately deep. The shore material is mainly bedrock, exposed approximately

4 feet above the average lake level. Above this, the bedrock is overlain by lacustrine clay. The relatively small and small lakes have somewhat irregular shorelines and are shallow to moderately deep. Shore materials consist mainly of organic matter with minor inclusions of exposed bedrock. These lakes are without open outlets, draining through bogs.

Landscape Unit 16 (90 sq. mi.)

Weakly broken area of bedrock-controlled outcrops, modified glacio-fluvial deposits and peat plains. The bedrock-controlled outcrops consist mainly of exposed bedrock, with lacustrine clay covering their lower sides. The sand-textured, water-modified, glacio-fluvial deposits are chiefly underlain by bedrock, whereas the peat plains are underlain mainly by lacustrine clay. Natural drainage of the land portion is in a south-westerly direction.

Land systems composing the land portion of this landscape unit are: 69-S; TS-69; 41; 29-FT; FS-69; FS-70; 69-TS.

Lakes cover 8 per cent of the landscape unit area situated within the boundaries of the Outlet Lakes Area. The various size classes of these lakes occupy the following proportion of the landscape unit:

Relatively small lakes:	7 %
Small lakes:	1 %

The lakes have somewhat irregular shorelines and are shallow to moderately deep. Shore materials consist mainly of organic matter and, less frequently, exposed bedrock. All lakes are without open outlets, draining through bogs.

Landscape Unit 17 (85 sq. mi.)

Weakly broken area of peat plains, and bedrock-controlled outcrops with infrequent glacio-fluvial deposits. Lacustrine clay mainly underlays the peat plains and also covers the sides of the bedrock-controlled outcrops. These outcrops contain a large proportion of exposed bedrock. Natural drainage of the land portion is mainly in a southerly direction.

Land systems composing the land portion of this landscape unit are: BkS; 79-S; TS-(49); SkF-29; BkS-(39); TS-29; 69-TS; SF-29; FS-30; BxS-29.

Lakes cover 6 per cent of the area. Lakes of various size classes occupy the following proportion of the landscape unit:

Relatively small lakes:	4 %
Small lakes:	2 %

The lakes have regular to somewhat irregular shorelines and are shallow. Organic matter is the principal shore material. The lakes are without open outlets, draining through bogs.

Landscape Unit 18 (2 sq. mi.)

Moderately broken area of bedrock-controlled outcrops and bouldery till. Peat deposits underlain by lacustrine clay occur in depressions. The bedrock-controlled outcrops consist mainly of exposed bedrock, lacustrine clay covering their lower sides. Natural land drainage is in a southwesterly direction.

Land systems composing the land portion of this landscape unit and situated within the boundaries of the Outlet Lakes study area are: SBx; TS-79; 41.

Lakes are absent within the confines of the Outlet Lakes study area.

Landscape Unit 19 (85 sq. mi.)

Weakly broken area of peat plains and coarse-textured, water-modified, glacio-fluvial deposits, containing infrequent bedrock-controlled outcrops. The peat plains and glacio-fluvial deposits are underlain chiefly by lacustrine clay and clay till. Natural drainage of the land portion is multi-directional, the major streams flowing in a north to northeasterly direction.

Land systems composing the land portion of this landscape unit are: 41; BkS-29; BkS-39; 79-ST; FBx; 80-S; 44; FS; TBk-49; F-(19); BkF; SBx.

Water covers 10 per cent of the landscape unit area situated within the boundaries of the Outlet Lakes study area. The various size classes of these lakes occupy the following proportion of the landscape unit:

Relatively small lakes:	9 % (East Nelson River channel)
Small lakes:	1 %

The lakes have somewhat irregular shorelines and are shallow to moderately deep. Organic matter and exposed bedrock are the principal shore materials. Some lakes are without open outlets, draining through bogs.

Landscape Unit 20 (17 sq. mi.)

Weakly broken area of modified glacio-fluvial deposits, peat plains, and bedrock-controlled outcrops. The glacio-fluvial deposits have a coarse texture and are underlain by lacustrine clay and bedrock. Lacustrine clay underlays the greater part of the peat plains. The bedrock-controlled outcrops consist of exposed bedrock at their apex, with lacustrine clay covering the remainder. Natural drainage of the land portion is in a southwesterly direction.

Within the boundaries of the study area, land systems composing the land portion of this landscape unit are: 41; BkS-69; FS-69.

Water covers 17 per cent of the area, 16 per cent of which constitutes a portion of the East Nelson River channel.

All lakes have regular to somewhat irregular shorelines and are shallow. The shore material is mainly organic matter. All lakes are without open outlets, draining through bogs.

Landscape Unit 21 (110 sq. mi.)

Weakly to moderately broken area of bedrock-controlled outcrops with peat plains in the depressions. The bedrock-controlled outcrops consist mainly of exposed bedrock; lacustrine clay being of minor significance. The peat plains are mainly underlain by lacustrine clay.

Land systems composing the land portion of this landscape unit are: 79-T; 69-TS; BkF-29; 39-BkF; TkF-49.

Water covers 50 per cent of the area, nearly all of which constitutes a portion of a large-size lake (Playgreen Lake). The size classes of the water bodies that occur in this landscape unit are 49% moderately large and 1% small.

The water body has an irregular shoreline and is moderately deep. Organic matter and exposed bedrock are the principal shore materials. The bedrock shore material is usually exposed approximately four feet above the average lake level, above which it is covered with lacustrine clay.

Landscape Unit 22 (115 sq. mi.)

Weakly broken area of bedrock-controlled outcrops and peat plains. The bedrock-controlled outcrops are comprised of exposed bedrock and laminated medium to coarse textured lacustrine deposits at the higher elevations, while lacustrine clay occurs at the lower elevations. The peat plains are mainly underlain by lacustrine clay.

Land systems composing the land portion of this landscape unit are: 49-FkT; Fk-49; F-49; 79-F; BkF-39; BkF-79· BkF-49; SkT-39: 79-Fk; 39.

Water covers 38 per cent of the area, the greater part of which constitutes a portion of large size lakes (Playgreen Lake, Kiskittogisu Lake). The various size classes of the water bodies occupy the following proportion of the landscape unit:

Moderately large lakes:	33 %
Relatively small lakes:	4 %
Small lakes:	1 %

The water bodies have irregular to somewhat irregular shorelines and are mostly moderately deep. Exposed bedrock and organic matter are the principal shore materials. The bedrock shore material is exposed up to about four feet above the average lake level, above which it is covered by unconsolidated geological deposits. The moderately large water bodies have an open outlet, while the relatively small ones drain through bogs.

Landscape Unit 23 (45 sq. mi.)

Weakly broken area of bedrock-controlled outcrops and peat plains. The bedrock-controlled outcrops consist chiefly of lacustrine clay with some exposed bedrock. The peat plains are mainly underlain by lacustrine clay. Natural drainage of the land portion is in a southwesterly direction.

Land systems composing the land portion of this landscape unit are: 79-FK; F-39; 49-FkT; Fk-49; F-49; 79-F.

Water covers 14 per cent of the area, some of which constitutes a portion of a large size lake (Kiskitto Lake). The various size classes of the water bodies occupy the following proportion of the landscape unit:

Moderately large lakes:	11 %
Relatively small lakes:	2 %
Small lakes:	1 %

The lakes have somewhat irregular shorelines and are moderately deep. Organic matter and exposed bedrock are the principal shore materials. Excepting Kiskitto Lake, all lakes lack an open outlet, but drain through bogs.

Landscape Unit 24 (135 sq. mi.)

Weakly broken area of peat plains, underlain by lacustrine clay, and bedrock-controlled outcrops. The bedrock-controlled outcrops are composed of exposed bedrock, laminated lacustrine deposits and lacustrine clay. Drainage of the land is partly in a northwesterly and partly in a southeasterly direction.

Land systems composing the land portion of this landscape unit are: BxS; FkS; BkS-39; ST-49; SBx-49; F-39; 39-BkS; BkF-49; 79-BkF; 79; 79-T.

Water covers 8 per cent of the area, a portion of which belongs to a moderately large size lake (Hill Lake). Lakes of various size classes occupy the following proportion of the landscape unit:

Relatively small lakes:	7 %
Small lakes:	1 %

The lakes have somewhat irregular shorelines and are shallow to moderately deep. Laminated lacustrine and lacustrine clay deposits are the principal shoreline materials of Hill Lake. The shore material of the other lakes consists mainly of organic matter and exposed bedrock. The latter lakes are without open outlets, draining through bogs.

Landscape Unit 25 (205 sq. mi.)

Weakly broken area of peat plains, underlain by lacustrine clay, and bedrock-controlled outcrops. These outcrops consist chiefly of lacustrine clay with some exposed bedrock. Natural drainage of the land portion is mainly in a northeasterly direction.

Land systems composing the land portion of this landscape unit are: BkS-(39); 80-BkF.

Lakes cover 9 per cent of the landscape unit area. The various lake-size classes occupy the following proportion of the landscape unit:

Relatively small lakes:	6 %
Small lakes:	3 %

The lakes have regular to somewhat irregular shorelines and are shallow. Organic matter and exposed bedrock are the principal shore materials. Some lakes have an open outlet, but most lakes drain through bogs.

Landscape Unit 26 (120 sq. mi.)

Very weakly to weakly broken area of peat plains, underlain by lacustrine clay, and bedrock-controlled outcrops. These outcrops are composed of exposed bedrock and laminated lacustrine deposits at the higher elevations, while lacustrine clay covers the lower flanks. Natural drainage of the land portion is primarily in a southwesterly direction.

Land systems composing the land portion of this landscape unit are: BkS-(39); 29-FS; BxS-79; SF-(40); 40-FS; 39-ST.

Water covers 20 per cent of the landscape unit area. Lakes of various size classes occupy the following proportion of the landscape unit:

Relatively small lakes:	14 %
Small lakes:	2 %

The lakes have irregular shorelines and are shallow to moderately deep. Exposed bedrock and organic matter are the principal shore materials. Some lakes have open outlets but most small lakes drain through bogs.

Landscape Unit 27 (105 sq. mi.)

Moderately broken area of bedrock-controlled lacustrine clay deposits with peat plains in the depressions. Drainage of the land portion is in an easterly or westerly direction, whereas the surface waters (Black Duck Creek) drain towards the north.

Land systems composing the land portion of this landscape unit are: 79-FkS; 39; SFk; S-79; 79-BkF; 79-ST; 89-FkT; FkT-89.

Water covers 13 per cent of the area. Lakes of various size classes occupy the following proportion of the landscape unit:

Relatively small lakes:	11 %
Small lakes:	2 %

The lakes have somewhat irregular shorelines and are shallow. Organic matter and exposed bedrock are the principal shore materials. All lakes, except the relatively small Drunken Lake, lack an open outlet, draining through bogs.

Landscape Unit 28 (100 sq. mi.)

Weakly to moderately broken area of bedrock-controlled lacustrine clay and peat plains underlain by lacustrine clay. Drainage of the land portion is in a northeasterly direction.

Land systems composing the land portion of this landscape unit are: 79-Tk; FS-49; SkT-39; BxF; BkF; SBx-39; BxF-79; BxF-39.

Lakes cover 15 per cent of the area. Lakes of various size classes occupy the following proportion of the landscape unit:

Relatively small lakes:	10 %
Small lakes:	5 %

The lakes have regular to somewhat irregular shorelines and are shallow to moderately deep. Organic matter is the main shore material. All lakes are without open outlets, draining through bogs.

Landscape Unit 29 (125 sq. mi.)

Weakly to moderately broken area of bedrock-controlled lacustrine clay and peat plains underlain by lacustrine clay. Natural drainage of the land portion is in a northeasterly direction, which is similar to the drainage direction of the surface waters (West Nelson River).

Land systems composing the land portion of this landscape unit are: 79-FT; 79-F; SkT-89; 79-SkT; BxF-89; TkF-40; 79-T.

Water covers 39 per cent of the area, part of which belong to large size lakes (Kiskittogisu Lake, Playgreen Lake). Lakes of various size classes occupy the following proportion of the landscape unit:

Moderately large lakes:	25 %
Relatively small lakes:	13 %
Small lakes:	1 %

The lakes have irregular to somewhat irregular shorelines and are shallow to moderately deep. Organic matter and exposed bedrock are the principal shore materials. All lakes, except the small ones, have open outlets.

Landscape Unit 30 (80 sq. mi.)

Weakly broken area of clay till and peat plains underlain by lacustrine clay. Sandy beach overlays of varying thickness are associated with the clay till material. Natural drainage of the land portion is in a northeasterly direction; the clay till moraine acting as a drainage barrier.

Land systems composing the land portion of this landscape unit are: BxF-40; 90; 39-Fk; BxF-39; BkS-40; 49-Sk; BkF-39; 40-T; 79-Sk; 80-BkF; 79-BkF.

Lakes occupy 9 per cent of the landscape unit area. Seven per cent of these lakes are relatively small; the remaining two per cent being small in size.

The lakes have somewhat irregular shorelines and are shallow to moderately deep. Organic matter is the main shore material, exposed bedrock being of lesser significance. All lakes are without open outlets, draining through bogs.

Landscape Unit 31 (70 sq. mi.)

Weakly to moderately broken area of clay till and bedrock-controlled outcrops of lacustrine clay. Peat plains occur in the depressions and are most prominent immediately adjacent to the till moraine. The clay till moraine is overlain in places by coarse-textured beach deposits of varying thickness. Natural drainage of the land portion is in southwesterly and northeasterly directions from the morainal high.

Land systems composing the land portion of this landscape unit are: 79-T; BxS-49; SkT-39; BkS; 90; 41; TBx-89; 90-T; SBk.

Water bodies occupy 19 per cent of the landscape unit area. All lakes are small in size, although a portion of these water bodies constitute a part of a large size lake (Playgreen Lake).

The lakes have regular to somewhat irregular shorelines and are shallow to moderately deep. Organic matter is the main shore material. Most lakes are without open outlets, draining through bogs.

Landscape Unit 32 (70 sq. mi.)

Very weakly broken area of clay till and peat plains underlain by lacustrine clay. The clay till moraine is overlain by coarse-textured beach deposits of varying thickness. Natural drainage of the land portion is in southwesterly and northeasterly directions from the morainal high. The peat plains are most prominent immediately adjacent to the till moraine.

Land systems composing the land portion of this landscape unit are: BkF-19; BkT-89; BkF; F-(19); 50; SBx; SF; BkF-29.

Lakes occupy 6 per cent of the landscape unit area and are all small in size.

The lakes have regular shorelines and are shallow to moderately deep. Organic matter is the main shore material. All lakes are without open outlets, draining through bogs.

Landscape Unit 33 (45 sq. mi.)

Weakly broken area of bedrock-controlled lacustrine clay outcrops with peat plains in the depressions. The peat plains are primarily underlain by lacustrine clay. Land-drainage is multi-directional while surface waters (East Nelson River) drain in a northerly direction.

Land systems composing the land portion of this landscape unit are: 69-SF; 41; FS-(19); 69-S; 79-TS; 79-S; FS-69.

Water covers 23 per cent of this landscape unit area, the lesser portion of which constituting lakes. These lakes are all small in size and occupy 3 per cent of this landscape unit.

The lakes have somewhat irregular shorelines and are shallow to moderately deep. Organic matter is the main shore material, exposed bedrock being of lesser importance. All lakes are without open outlets, draining through bogs.

Landscape Unit 34 (230 sq. mi.)

Moderately broken area of bedrock-controlled, lacustrine clay outcrops with peat plains in the depressions. The peat plains are mainly underlain by lacustrine clay. Land as well as surface water drainage is in a northeasterly direction.

Land systems composing the land portion of this landscape unit area: SkT-39; 79-T; 79-FBk; BkT-89; 89-SkT; SBk; 79-BkS; 79-ST; SFb-89.

Water covers 30 per cent of this landscape unit area; the lesser portion constituting surface water drainage (East Nelson River channels). Lakes of various size classes occupy the following proportion of this landscape unit:

Moderately large lakes:	22 %	(Pipestone Lake, Cross Lake, in part)
Relatively small lakes:	6 %	
Small lakes:	2 %	

The lakes have irregular shorelines and the large ones are moderately deep; the small lakes being shallow to moderately deep. The shore materials of the large size lakes consist primarily of exposed bedrock with some clay and organic matter. The small lakes have dominantly organic shore material. The large-size lakes have open outlets whereas the small ones drain through bogs.

Landscape Unit 35 (100 sq. mi.)

Weakly broken area of bedrock-controlled, lacustrine clay outcrops, and peat plains underlain by lacustrine clay. Natural drainage of the land surface is in a northeasterly direction.

Land systems composing the land portion of this landscape unit are: 79-TF; BkF-29; F-29; 29-FS; 80-TF; TF-79.

Lakes cover 20 per cent of the landscape unit area situated within the boundaries of the Outlet Lakes study area. The various size classes of these lakes occupy the following proportion of the landscape unit:

Relatively small lakes: 10 %
Small lakes: 10 %

The lakes have somewhat irregular shorelines and are shallow to moderately deep. Organic matter and exposed bedrock are the principal shore materials. All lakes within the boundaries of the Outlet Lakes Study area are without open outlets, draining through bogs.

Landscape Unit 36 (245 sq. mi.)

Weakly to moderately broken area of lacustrine clay plains with occasional occurrences of exposed bedrock. Peat plains occur in the depressions and also overlay large areas of the lacustrine plains. Natural drainage of the land portion is multi-directional, whereas surface water drainage (Nelson River) is in northeasterly and westerly directions.

Land systems composing the land portion of this landscape unit are: 79-Sk; 79; BkF-79; BkS-79; TSk-49; BkF-39; 79-T; 79-BkF; BkF-49; 49-T; 90; 79-TF.

Water covers 39 per cent of the landscape unit area situated within the boundaries of the Outlet Lakes study area. The various size classes of the lakes occupy the following proportion of the landscape unit:

Large lakes: 36 % (Cross Lake, in part)
Small lakes: 3 %

The large lakes have irregular shorelines and are deep; whereas the small ones have regular shorelines and are shallow. Exposed bedrock is the principal shore material of the large lakes; however, lacustrine clay is normally found within about four feet above the average lake level. The small lakes normally have organic matter as shore material. The large lakes have open outlets while the small ones drain through bogs.

APPENDIX 3 - B

FOREST RESOURCE INVENTORY OF: THE AREA BETWEEN THE 715 FOOT ELEVATION CONTOUR AND THE WEST CHANNEL AND THE AREA TO BE EXCAVATED FOR 2-MILE, 8-MILE AND OMINAWIN BYPASS CHANNELS

FOREST RESOURCE INVENTORY OF:
THE AREA BETWEEN THE 715-FOOT ELEVATION CONTOUR AND THE WEST CHANNEL
AND
THE AREA TO BE EXCAVATED FOR 2-MILE, 8-MILE AND OMINAWIN BYPASS CHANNELS

by

R. H. LAMONT* and M. KAYE**
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba
January, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

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*Chief, Resource Inventory,
Surveys Branch

**Chief,
Forest Research,
Research Branch.

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SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

ABSTRACT

An estimated total land area of 22,928 acres and gross merchantable volume of 163,450 cunits will be lost to flooding and channel construction in the Outlet Lakes System and West Channel of the Nelson River at the North end of Lake Winnipeg. Brief descriptions of forest cover in the study area and survey methods are given. A detailed examination of land area and wood volume to be lost is given based on status of land and further subdivided by amount to be flooded up to the 715' contour and amount to be lost through channel construction.

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SUMMARY

I. Recommendations

A major effort should be made to salvage and utilize the merchantable wood volume to be lost to flooding in the Project Area.

Clearing of all vegetation to be flooded in the entire Project Area is not a forestry requirement.

Concentration of channel effluent in low-lying, non-productive areas will minimize damage to productive forest land.

II. Objectives

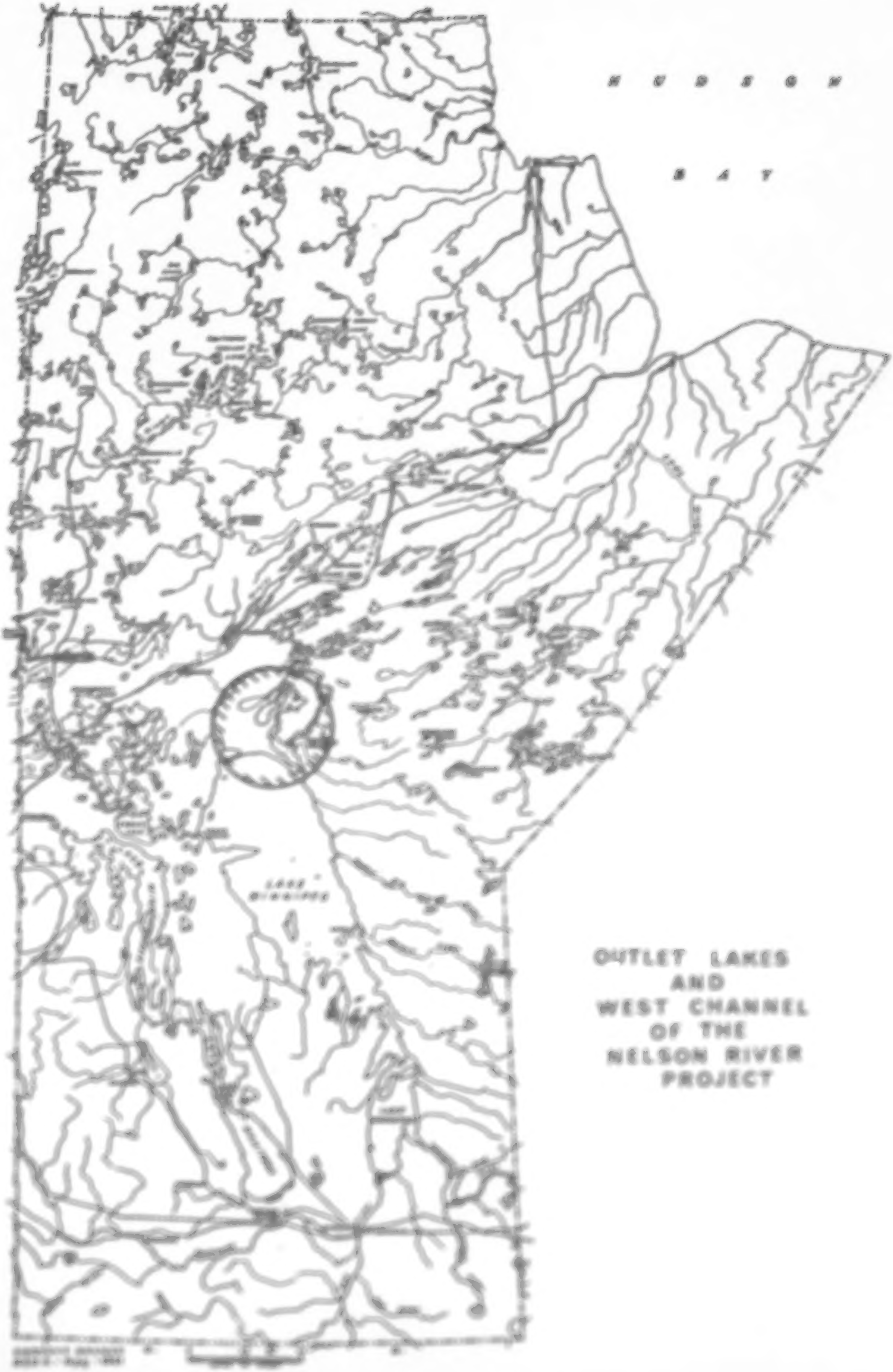
The objectives are to describe the forest cover to determine area and volume losses and to assess the implications of these losses in the two Forest Management Units involved.

III. Terms of Reference

The study will give the areas and volumes to be lost through flooding and channel construction in the Project Area including an examination of expected beneficial and detrimental effects.

IV. Study Area

The study area covered by this report is described as the Outlet Lakes System and the West Channel of the Nelson River as shown on the project location map. This includes all land to be flooded to the 715' contour and lands to be lost due to the construction of the two-mile, eight-mile and Ominawin Channels.


HUDSON BAY
LAKE WINNIPEG

OUTLET LAKES
AND
WEST CHANNEL
OF THE
NELSON RIVER
PROJECT

All lands in the study area are Provincial Crown Lands. Of the total land area to be lost in the Project Area, 46.5% (16.7 square miles) falls within the Specified Area of Churchill Forest Industries (Manitoba) Limited, and 53.5% (19.1 square miles) falls within the forest option area of Marine Transport Limited.

V. Methodology

Land areas and forest volumes were classified, measured and analyzed on the basis of standard forest inventory procedures used by the Province of Manitoba. The area to be flooded was determined by superimposing the 715-foot contour line and channel locations on 1" = 1 mile forest cover maps produced by Forest Inventory.

VI. Observations

The total area to be lost through flooding and channel construction is 22,920 acres or 35.8 square miles.

The productive forest area to be lost will be 13,225 acres (20.7 square miles) or 57.7% of the total land area.

The total Gross Merchantable Volume of all species to be lost is estimated to be 163,160 cunits (100's of cubic feet).

The total Net Merchantable Volume of all species to be lost is estimated to be 117,790 cunits.

The total Net Merchantable Volume of Softwood (Conifer) species only, is estimated to be 106,120 cunits.

The total Net Operable Volume of the four major softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) is estimated to be 18,290 cunits.

Beneficial effects are related primarily to improved forest access due to road development and expected improved barge transport possibilities.

Detrimental effects include a reduction in the annual allowable cut for black spruce (1% to 2%) and white spruce (9%) in Forest Management Units 82 and 83. This reduction is within acceptable limits previously established for each Management Unit. Manipulation of water flows in the winter period may restrict or prohibit winter logging activity requiring ice crossings in the Project Area. This effect will be minimized if adequate winter road networks are established in conjunction with a permanent crossing over the Nelson River at Jen-Peg.

VII. Conclusions

The effect of Hydro development on the Outlet Lakes and West Channel of the Nelson River will cause losses in Gross Merchantable wood volume of 163,450 cunits and an area loss of 22,928 acres.

The loss of Net Operable Volume of the four major softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) consists of 5,920 cunits (12%) of 5" diameter material, 23,940 cunits (50%) of 6"-9" diameter material and 18,420 cunits (38%) of the 10"+ diameter material for a total of 48,280 cunits.

A major attempt should be made to salvage and utilize the wood volume to be lost due to flooding.

The effect on forest vegetation of sediment deposition through channel construction could not be adequately determined at this time. This will be completed when precise definition of the extent of the area to be affected can be made.

Timber Clearing and Salvage Study of the Outlet Lakes System and West Channel of the Nelson River

I. Recommendations

A major effort should be made to salvage and utilize the merchantable wood volume to be lost to flooding and construction in the project area. Agencies involved with clearing of specific areas under contract to Manitoba Hydro should be encouraged to salvage the merchantable wood volume on their contract areas for utilization by established industries including Churchill Forest Industries, Abitibi Manitoba Paper Company, and local sawmills in the Norway House area.

Removal of forest cover from shoreline areas open to public access by road and future recreation developments is important. Areas around the tips of major points of land where boat travellers will be required to change direction should be cleared for safety purposes related to wind problems. Consideration should be given to clearing additional emergency access corridors (at least 200 feet wide) through areas to be flooded to high ground.

Clearing of vegetative cover over the entire project area is not a requirement based on forestry needs.

The concentration of channel effluent in low-lying, non-productive (treed muskeg or muskeg) areas will minimize damage to Productive Forest Land. An examination of areas affected by sediment deposition will be made by Forest Inventory after construction has been completed.

II. Objectives

The objectives of the study conducted by Forest Inventory on the forest resource within the Jen-Peg project area are as follows:

1) To analyze tree characteristics which determine volume and to study the composition of the forest resource to obtain an accurate evaluation of the type of the resource present in the project area.
2) To determine the area of land and the amount of volume to be lost through the proposed flooding and the effect which this loss will have on the total practical allowable cut of the area.
3) To assess the implications of the losses on the forest resource in the Project Area and to make recommendations according to conclusions derived from the study.

III. Terms of Reference

The terms of reference as outlined in the study proposal are based on the assumption that all timber stands below the high water contour (715') will be lost. The forest inventory data produced in the study will give the following:

1) Total area to be affected by flooding
2) Area classification with respect to forest productivity
3) Merchantable volume of all species
4) Merchantable volume of softwood species
5) Merchantable volume of operable softwood stands
6) Examination of beneficial effects
7) Examination of detrimental effects

IV. Study Area

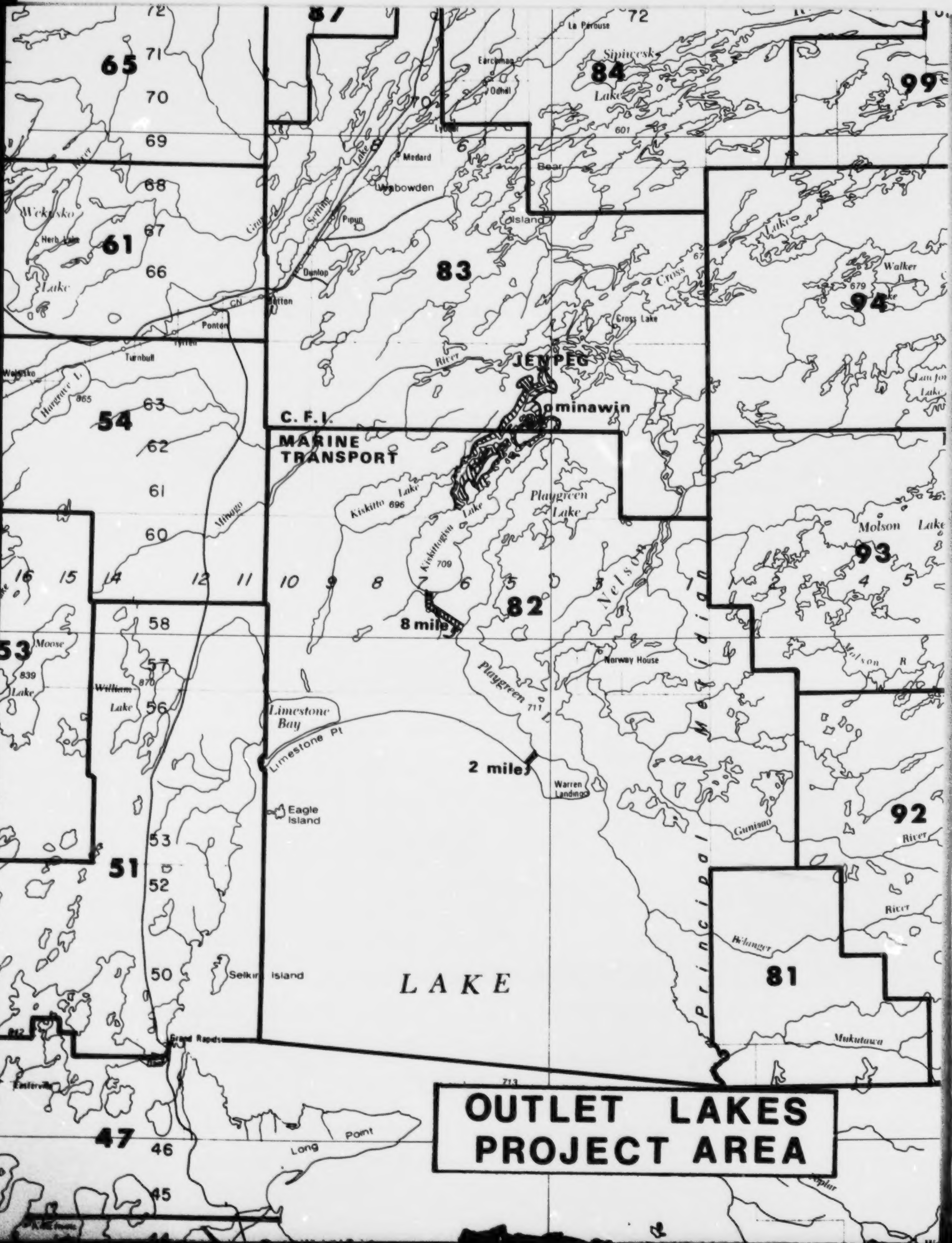
The Outlet Lakes System and West Channel of the Nelson River are located at the North end of Lake Winnipeg. The study area represents the area to be affected by the Manitoba Hydro control structure at Jen-Peg located approximately where the West Channel of the Nelson River enters Cross Lake. Two causes of forest loss will be encountered. The primary cause for forest loss will be the raising of water to the 715 foot contour line. The secondary cause for forest loss will be the construction of channels for improved water movement. The resulting channel effluent will represent a third-order effect upon the forest resource which cannot be quantified until the actual dumping of sediment has taken place.

Areas set aside for channel sediment deposition appear to be far in excess of the actual areas required. Calculations of area and wood volume to be lost or gained through this action would be very misleading through over-emphasis, and therefore, this aspect of construction does not form part of this report.

Three channels are included in this report: 2-mile, 8-mile and Ominawin.

Location and Status

The project area is located astride the boundary between Forest Management Units 82 and 83 as shown on the location map. The forest area and volume located in Forest Management Unit 83 are presently committed to Churchill Forest Industries (Manitoba) Limited (C.F.I.) as part of the



OUTLET LAKES PROJECT AREA

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Sipiwesk
Lake
Odhill
601
Lyddal
Medard
Wabowden
Setting
Lake
Pipun
Dunlop
Thicket Portage
Bear
Island
Cross
Cross Lake
Walker
679
Lake
JENPEG
ominawin
C. F. I.
MARINE
TRANSPORT
River
Wekusko
Herb Lake
Lake
Wekusko
Hargrave L.
865
Turnbull
Ponton
CN
Minago
Kiskitto Lake
696
Kiskittogisu Lake
709
Playgreen Lake
Nelson
Meridian
Principal
Molson Lake
Molson R
8 miles
Norway House
Playgreen L
711
2 miles
Warren Landing
Limestone Bay
Limestone Pt
Eagle Island
Moose
839
Lake
William
870
Lake
Gunisao
River
River
Belanger
Mukutawa
Selkirk Island
LAKE
812
Grand Rapids
Easterville
713
Long Point

specified area outlined in a memorandum of agreement entered into on February 24, 1966. The forest area and volume located in Forest Management Unit 82 is under option to Marine Transport Limited. This company has not as yet taken advantage of the option.

All lands within the project area are Provincial Crown Lands. No other ownerships are encountered.

V. Methodology

The Forest Resource Inventory of all portions of the Jen-Peg Project area is of a recent, detailed nature. Aerial photography over the area at a scale of four inches to one mile (1:15,840) was obtained over the three-year period - 1965, 1966 and 1967.

The field survey was carried out under contract to Lockwood Survey Corporation and Forestal for that portion of the project area lying within the Specified Area of Churchill Forest Industries (Manitoba) Limited. This contract work and subsequent compilation of data by the Forest Inventory Group of the Province was completed in December, 1969.

The field survey of the portion of the study area within Forest Management Unit 82 was carried out by the Forest Inventory Group of the Province to determine the extent of the Forest Resource in the area for possible development by Marine Transport. This area was completed in December, 1970.

The following summary is presented to provide an indication of the scope and detail of the forest resources in the project area. Complete details of the method of field survey and descriptions of the classification system used is presented in the field cruising manual prepared by the

Forest Resource Inventory Section.

Section corners and preliminary typing of the forest stand boundaries were delineated on aerial photographs. Forest types are based on species composition, site, cutting class (maturity) and crown closure (density). Base maps were prepared at a scale of four inches to one mile based on ground control established by the Surveys Branch. Detail from the aerial photographs was then transferred by sketchmaster to the base maps. The forest cover so delineated was identified by number on a Township basis and photointerpreted.

Prism sample plots were established in a variable percentage of the stands identified on the aerial photographs. All species of trees counted in the sample plot were measured for height and diameter breast height (D.b.h.). In addition, the age of one or more trees on each plot was counted to give an age of the stand. Volume per acre estimates were prepared based on the field measurements.

Areas in acres for all stands delineated were determined and the volumes per acre were applied from the appropriate stand/stock volume table giving the expanded wood volumes for the area under consideration.

As a result, all type aggregates of cutting class 3 (lowest classification with recognized volume) and higher are based on volumes determined from variable numbers of sample plots which have been measured in the area and which have been located in stands having as similar characteristics as could possibly be determined.

Lands presently not restocked were classified as to site and the most suitable species which the site could support so that possible reforestation programs could be developed for specific areas or the Forest Management Unit as a whole.

Reduced copies of the original four-inch to one-mile forest inventory maps at a scale of one inch to one mile have been prepared for the management units as a final step.

Aerial photomosaics were prepared at a scale of four inches to one mile and are stored at the Regional Office at The Pas. Reduced mosaics were made at a scale of two inches to one mile and copies are stored at The Pas and at The Forest Inventory office in Winnipeg.

The 715' contour line and the areas cleared for channel construction were transferred to forest inventory maps at a scale of four inches to one mile. Areas of land to be lost were then calculated. Wood volumes involved were determined by applying the productive areas to be lost in acres against the respective stand/stock volume tables covering the two Forest Management Units involved.

Stand/Stock Volume Tables

Two stand/stock volume tables are used to provide estimates of volume for the project area. The first volume table was developed for Forest Management Units 83, 84, 85 and 86 which fall within the Specified Area of Churchill Forest Industries (Manitoba) Limited. The volume table is based on trees measured on 10,310 sample plots located throughout the four Management Units.

The second stand/stock volume table was developed for Forest Management Units 81 and 82. This volume table is based on trees measured on 4,320 sample plots located throughout the two Management Units.

A summary of plots established and number of forest stands sampled specifically in the Townships to be affected by the Jen-Peg project is as follows:

Township and Range	Stands Sampled	Plots Established
58-6 WPM	2	10
59-7 WPM	1	10
61-6 WPM	18	126
61-7 WPM	19	145
62-4 WPM	4	20
62-5 WPM	25	179
62-6 WPM	20	111
Sub-Total Marine Transport Portion	89	601
63-4 WPM	2	20
63-5 WPM	17	128
64-4 WPM	24	236
64-5 WPM	9	70
Sub-Total Churchill Forest Industries Portion	52	454
Total Sampled in Project Area Only - 11 Townships	141	1,055

Rotation Period

Rotation periods used for the Forest Management Units within which the Project Area falls were determined on the basis of present market conditions for the various species and the size and type of products for which the species are most suited.

The following rotation ages apply to the various working groups:

Jack Pine, All Sites	-	80 Years
Black Spruce, Site I	-	80 Years
Black Spruce, Site II	-	140 Years
Black Spruce, Site III	-	140 Years
White Spruce, All Sites	-	100 Years
Balsam Fir, All Sites	-	80 Years
Hardwood, All Sites	-	80 Years

For reference purposes the following Age Distributions by Cutting Classes are provided for each working group encountered in the Project Area. This information gives the approximate age range in years for each cutting class of each working group.

TABLE I

Age Distribution in Years by Cutting Classes and Working Groups

Working Group	Cutting Class				
	1	2	3	4	5
Jack Pine All Sites	1-10	11-25	26-70	71-90	91+
Black Spruce Site I	1-15	16-30	31-70	71-90	91+
Black Spruce Site II & III	1-30	31-75	76-120	121-160	161+
White Spruce All Sites	1-20	21-30	31-90	91-110	111+
Balsam Fir All Sites	1-10	11-25	26-70	71-90	91+
Hardwoods All Sites	1-15	16-30	31-70	71-90	91+

VI. Observations

Forest Description

The Jen-Peg Project Area falls within the western portion of the Nelson River Forest Section as defined by J. S. Rowe[1]. The following general description presented by Rowe, briefly describes the characteristics of the Forest Section.

> "Stands of black spruce (Picea mariana) make up a large part of the forest cover, but proximity to the numerous and extensive swamps that lie back from the rivers is reflected in a restriction of growth. Where drainage is better as along the sides of rivers, on islands or on low ridges, good stands of white spruce (Picea glauca) with some balsam poplar (Populus balsamifera), white birch (Betula papyrifera), aspen (Populus tremuloides), and balsam fir (Abies balsamea) are customary, with possibly more aspen and balsam poplar under such conditions on the east side of Lake Winnipeg. Extensive and repeated fires have, however, fragmented all the forest cover, and large areas support small-growth aspen, white birch, and scattered white and black spruce, or jack pine (Pinus banksiana) and aspen, or grassy scrub on rocky barrens. Tamarack (Larix laricina) is present with black spruce in the swamps.
>
> The area was covered by glacial Lake Agassiz, and the consequent deposition of lacustrine clays and sands has had the effect of levelling what was formerly an irregular and rolling Precambrian surface. The lacustrine deposits are shallow on the rocky uplands and deeper in the valleys, extending back along the latter considerable distances from the present-day lakes. On the well-drained materials, podzolic profiles normally develop. Podzolic gleysols are typical of poorly drained slopes, while moss and woody peat characterize the spruce-tamarack muskegs."

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1. Rowe, J. S. Forest Regions of Canada, Canada Department of Northern Affairs and National Resources - Forestry Branch, Bulletin 123, 1959.

Stands of trees encountered in the South and South Eastern portion of the project area are relatively small and widely scattered. Stands in the Northwestern portion are generally larger in area and corresponding volume.

Black Spruce predominates in the Project Area followed by Trembling Aspen, White Spruce, Jack Pine, Balsam Fir, White Birch and Balsam Poplar ranked in order of decreasing volume.

Table II is presented to summarize the characteristics of the various forest working groups encountered in the Project Area.

Area to be Lost by Flooding and Channelling

The area to be lost through flooding to the 715' contour and the construction of the two-mile, eight-mile and Ominawin channels has been calculated. The total land area to be lost through flooding and channelling totals 22,928 acres or 35.8 square miles.

The total area involved has been summarized and is presented in Tables III and IV. A detailed breakdown of productive forest area only is presented in the following section under Tables V, VI and VII.

Statistical reports covering the project area calculations as produced by computer are presented with the original report only, under separate cover as Appendix I.

TABLE II

Characteristics of Working Groups Found in the Outlet Lakes Project Area

Working Group	Site	Primary Species	Associate Species	Rotation in Years	Dbh Range at Rotation	Height Range at Rotation	Gross Merchantable Volume (per acre) Range at Rotation (All Species)	Landform	Soil Moisture	Drainage
Jack Pine	I	Jack Pine	Black Spruce Trembling Aspen White Birch	80	6"-15"	55'-70'	17 to 22 cunits per acre	Slopes, Intermediate terraces and small rock outcrops	Fresh to moist	Good
Black Spruce	I	Black Spruce	White Spruce Trembling Aspen Jack Pine	80	6"-14"	45'-65'	12 to 19 cunits per acre	Low glacial till ridges and lacustrine flats	Moist to wet	Good
Black Spruce	II	Black Spruce	Tamarack Larch Balsam Poplar	140	4"-8"	30'-45'	7 to 12 cunits per acre	Flat, deep organic terrain	Wet to saturated	Insufficient
Black Spruce	III	Black Spruce	Jack Pine Trembling Aspen Balsam Poplar White Birch	140	4"-8"	30'-45'	7 to 14 cunits per acre	Associated with rock outcrops	Fresh to dry	Excessive
White Spruce	I	White Spruce	Trembling Aspen Balsam Fir Black Spruce White Birch	100	10"-25"	55'-85'	30 to 45 cunits per acre	Lacustrine flats immediately adjacent to rivers and lakes	Moist to fresh	Good
Balsam Fir	I	Balsam Fir	White Spruce Black Spruce Trembling Aspen Balsam Poplar White Birch	80	6"-15"	45'-65'	15 to 20 cunits per acre	Lacustrine flats immediately adjacent to rivers and lakes	Moist to fresh	Good
Hardwood	I	Trembling Aspen Balsam Poplar White Birch	White Spruce Black Spruce Balsam Fir Jack Pine	80	8"-20"	55'-75'	15 to 20 cunits per acre	Slopes and intermediate terraces, lacustrine flats	Fresh to very moist	Good

NOTE: FOR MAP ILLUSTRATING

MERCHANTABLE TIMBER STANDS

IN JENPEG AREA

CONTACT AUTHOR

Table III gives the area to be lost due to flooding and channelling by Township and Range.

TABLE III

Area of Townships to be Lost by Flooding and Channelling*

By Ownership and Status of Land

(in Acres)

Township	Churchill Forest Industries		Marine Transport		Total
	Provincial Crown		Provincial Crown		Provincial Crown
	To 715' Contour	Channel*	To 715' Contour	Channels*	
55-4 WPM	--	--	--	105	105
55-5	--	--	--	172	172
58-6 WPM	--	--	--	403	403
58-7	--	--	--	174	174
59-7 WPM	--	--	--	83	83
61-6 WPM	--	--	3,148	--	3,148
61-7	--	--	22	--	22
62-4 WPM	--	--	595	--	595
62-5	--	--	3,807	--	3,807
62-6	--	--	3,752	--	3,752
63-4 WPM	2,629	--	--	--	2,629
63-5	5,065	170	--	--	5,235
64-4 WPM	2,088	--	--	--	2,088
64-5	715	--	--	--	715
Total Land Area (in Acres)	10,497	170	11,324	937	22,928
Square Miles	16.4	0.3	17.7	1.4	35.8
Percent of Total	45.8	0.7	49.4	4.1	100.0

*Does not include area lost or gained due to deposit of channel sediment.

Table IV indicates the area by productivity to be lost through flooding and channelling in the Project Area.

The total area to be lost through water regulation in the Outlet Lakes and West Channel of the Nelson project area is 22,928 acres or 35.8 square miles.

Churchill Forest Industries (Manitoba) Limited will lose 10,497 acres or 16.4 square miles due to flooding to the 715-foot contour and 170 acres or 0.3 square miles due to the construction of the Ominawin Channel. This represents an area loss of 10,667 acres or 16.7 square miles of which 6,774 acres or 63.5 percent are classed as Forest Productive Land.

Marine Transport will lose 11,324 acres or 17.7 square miles due to flooding to the 715-foot contour and 937 acres or 1.4 square miles due to the construction of the two-mile and eight-mile channels. This represents an area loss of 12,261 acres or 19.1 square miles of which 5,245 acres or 42.8 percent are classed as Forested Productive Land.

Productive Forest Area

The productive forest area to be lost due to flooding to the 715' contour and the construction of channels has been summarized and is presented in Tables V, VI and VII. In the tables, productive area describes the total productive area to be lost from cutting class 0 (potentially productive) to cutting class 5 (overmature). Net Operable Area refers to productive area in cutting classes 4 and 5 having a minimum net merchantable volume of 8 cunits per acre of Jack Pine, Black Spruce, White Spruce and Balsam Fir together, 5 inches and over in diameter at breast height. Net Operable Area, therefore, is the best of the mature and overmature (cutting class 4 and 5) portions of the productive area summary.

TABLE IV

Area to be Lost Through Flooding and Channelling*

By Productivity, Ownership and Status of Land

(in Acres)

Type (Working Group)	Churchill Forest Industries		Marine Transport		Total Area	% of Productive	% of Total Area
	Provincial Crown		Provincial Crown				
	To 715' Contour	Channel*	To 715' Contour	Channels*			
Jack Pine, All Sites	256	--	71	--	327	2.7	
Black Spruce, Site I	3,403	27	2,673	116	6,219	51.5	
Black Spruce, Site II	1,373	30	345	54	1,802	14.9	
Black Spruce, Site III	51	--	13	--	64	0.5	
White Spruce, All Sites	373	--	476	23	872	7.2	
Balsam Fir, All Sites	--	--	7	38	45	0.4	
Total Softwood	5,456	57	3,585	231	9,329	77.2	40.7
Hardwoods, All Sites	1,261	--	1,421	8	2,690	22.3	11.7
Total Forested Productive	6,717	57	5,006	239	12,019	99.5	52.4
c.c.o. Jack Pine	--	--	--	--	--		
c.c.o. Black Spruce Site I	2	--	27	--	29	0.3	
c.c.o. Black Spruce Site II	--	--	--	--	--		
c.c.o. White Spruce	--	--	27	--	27	0.2	
Total Potential Productive	2	--	54	--	56	0.5	0.3
Total Productive	6,719	57	5,060	239	12,075	100.0	52.7

TABLE IV (Cont'd)

Type (Working Group)	Churchill Forest Industries		Marine Transport		Total Area	% of Productive	% of Total Area
	Provincial Crown		Provincial Crown				
	To 715' Contour	Channel*	To 715' Contour	Channels*			
Treed Muskeg (700)	2,803	113	4,940	432	8,288		
Willow & Alder (720)	346	--	714	51	1,111		
Protection Forest (730)	51	--	251	--	302		
Total Forested Non-Productive	3,200	113	5,905	483	9,701	--	42.3
Marsh-Muskeg (820)	578	--	333	215	1,126		
Unclassified (840)	--	--	26	--	26		
Total Non-Forested	578	--	359	215	1,152	--	5.0
Total Land Area (Acres)	10,497	170	11,324	937	22,928	--	100.0
Square Miles	16.4	0.3	17.7	1.4	35.8	--	
Percent of Total	45.8	0.7	49.4	4.1	100.0	--	

TABLE V

Summary of Distribution of Area by Working Groups and Cutting Class

Churchill Forest Industries

(in Acres)

Working Group	Site	Productive Area							Net Operable Area		
		Cutting Class							Cutting Class		
		0	1	2	3	4	5	Total	4	5	Total
Jack Pine	All	--	--	3	63	163	27	256	163	27	190
Black Spruce	I	2	7	203	2,008	917	295	3,432	917	295	1,212
Black Spruce	II & III	--	59	409	986	--	--	1,454	--	--	--
White Spruce	All	--	--	--	21	107	245	373	107	245	352
Total Softwood	--	2	66	615	3,078	1,187	567	5,515	1,187	567	1,754
Total Hardwood	--	--	--	48	256	941	16	1,261	322	--	322
Total	--	2	66	663	3,334	2,128	583	6,776	1,509	567	2,076
Percent of Total	--	--	1.0	9.8	49.2	31.4	8.6	100.0	72.7	27.3	100.0

TABLE VI

Summary of Distribution of Area by Working Groups and Cutting Class

Marine Transport

(in Acres)

Working Group	Site	Productive Area							Net Operable Area		
		Cutting Class							Cutting Class		
		0	1	2	3	4	5	Total	4	5	Total
Jack Pine	All	--	--	14	57	--	--	71	--	--	--
Black Spruce	I	27	18	596	1,383	696	96	2,816	607	92	699
Black Spruce	II & III	--	10	44	353	5	--	412	--	--	--
White Spruce	All	27	--	--	21	450	28	526	450	28	478
Balsam Fir	All	--	--	--	--	45	--	45	7	--	7
Total Softwood	--	54	28	654	1,814	1,196	124	3,870	1,064	120	1,184
Total Hardwood	--	--	149	263	739	239	39	1,429	91	39	130
Total	--	54	177	917	2,553	1,435	163	5,299	1,155	159	1,314
Percent of Total	--	1.0	3.3	17.3	48.2	27.1	3.1	100.0	87.9	12.1	100.0

TABLE VII

Summary of Distribution of Area by Working Groups and Cutting Class

Total Area

(in Acres)

Working Group	Site	Productive Area							Net Operable Area		
		Cutting Class							Cutting Class		
		0	1	2	3	4	5	Total	4	5	Total
Jack Pine	All	--	--	17	120	163	27	327	163	27	190
Black Spruce	I	29	25	799	3,391	1,613	391	6,248	1,524	387	1,911
Black Spruce	II & III	--	69	453	1,339	5	--	1,866	--	--	--
White Spruce	All	27	--	--	42	557	273	899	557	273	830
Balsam Fir	All	--	--	--	--	45	--	45	7	--	7
Total Softwood	--	56	94	1,269	4,892	2,383	691	9,385	2,251	687	2,938
Total Hardwood	--	--	149	311	995	1,180	55	2,690	413	39	452
Total	--	56	243	1,580	5,887	3,563	746	12,075	2,664	726	3,390
Percent of Total	--	0.4	2.0	13.1	48.8	29.5	6.2	100.0	78.6	21.4	100.0

Gross Merchantable Volume

Gross Merchantable Volume estimates of wood to be lost in the Jen-Peg project area are given in Tables VIII, IX and X. The Gross Merchantable Volume is the volume of all species with diameter 3.6 inches at breast height and larger and is calculated on the basis of a 12-inch stump and the following specified top diameters:

a) Jack Pine, Black Spruce and White Spruce - top diameter 3"

b) Balsam Fir, Tamarack Larch and Hardwood species - top diameter 4"

The Gross Merchantable Volume estimate indicates the total wood volume available in Intermediate, Mature and Overmature stands (Cutting Classes 3, 4 and 5) in the project area.

Statistical Reports covering wood volume in the project area as produced by computer analysis are presented with the original report only, under separate cover as Appendix II.

TABLE VIII

Gross Merchantable Volume

(in Cunits)

Species	Churchill Forest Industries						Total		
	To 715' Contour			Channels					
	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total
Jack Pine	3,820	1,690	5,510	10	--	10	3,830	1,690	5,520
Black Spruce	41,260	3,180	44,440	330	30	360	41,590	3,210	44,800
White Spruce	4,930	10,690	15,620	10	20	30	4,940	10,710	15,650
Balsam Fir	2,470	550	3,020	--	--	--	2,470	550	3,020
Tamarack Larch	170	40	210	--	--	--	170	40	210
Total Softwood	52,650	16,150	68,800	350	50	400	53,000	16,200	69,200
Trembling Aspen	17,630	7,450	25,080	10	--	10	17,640	7,450	25,090
Balsam Poplar	2,000	1,050	3,050	--	--	--	2,000	1,050	3,050
White Birch	2,660	520	3,180	--	--	--	2,660	520	3,180
Total Hardwood	22,290	9,020	31,310	10	--	10	22,300	9,020	31,320
Total	74,940	25,170	100,110	360	50	410	75,300	25,220	100,520

TABLE IX

Gross Merchantable Volume

(in Cunits)

Species	Marine Transport						Total		
	To 715' Contour			Channels					
	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total
Jack Pine	1,230	450	1,680	20	20	40	1,250	470	1,720
Black Spruce	22,970	2,380	25,350	1,380	160	1,540	24,350	2,540	26,890
White Spruce	4,610	9,150	13,760	230	480	710	4,840	9,630	14,470
Balsam Fir	1,700	310	2,010	350	40	390	2,050	350	2,400
Tamarack Larch	100	10	110	10	--	10	110	10	120
Total Softwood	30,610	12,300	42,910	1,990	700	2,690	32,600	13,000	45,600
Trembling Aspen	8,520	3,930	12,450	250	200	450	8,770	4,130	12,900
Balsam Poplar	1,200	600	1,800	50	10	60	1,250	610	1,860
White Birch	2,020	400	2,420	120	30	150	2,140	430	2,570
Total Hardwood	11,740	4,930	16,670	420	240	660	12,160	5,170	17,330
Total	42,350	17,230	59,580	2,410	940	3,350	44,760	18,170	62,930

TABLE X

Gross Merchantable Volume

(in Cunits)

Species	Total Project Area						Total		
	CFI			Marine Transport					
	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total
Jack Pine	3,830	1,690	5,520	1,250	470	1,720	5,080	2,160	7,240
Black Spruce	41,590	3,210	44,800	24,350	2,540	26,890	65,940	5,750	71,690
White Spruce	4,940	10,710	15,650	4,840	9,630	14,470	9,780	20,340	30,120
Balsam Fir	2,470	550	3,020	2,050	350	2,400	4,520	900	5,420
Tamarack Larch	170	40	210	110	10	120	280	50	330
Total Softwood	53,000	16,200	69,200	32,600	13,000	45,600	85,600	29,200	114,800
Trembling Aspen	17,640	7,450	25,090	8,770	4,130	12,900	26,410	11,580	37,990
Balsam Poplar	2,000	1,050	3,050	1,250	610	1,860	3,250	1,660	4,910
White Birch	2,660	520	3,180	2,140	430	2,570	4,800	950	5,750
Total Hardwood	22,300	9,020	31,320	12,160	5,170	17,330	34,460	14,190	48,650
Total	75,300	25,220	100,520	44,760	18,170	62,930	120,060	43,390	163,450

Net Merchantable Volume

Net Merchantable Volume estimates of wood to be lost in the Jen-Peg Project Area are given in Tables XI, XII, and XIII. The Net Merchantable Volume is determined by applying cull factors to cover decay, breakage and harvesting loss to be expected in the area. The following cull factors apply in the study area.

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black and White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
All Hardwoods	20%	40%

TABLE XI

Churchill Forest Industries

Net Merchantable Volume

(in Cunits)

Species	Churchill Forest Industries								
	To 715' Contour			Channel			Total		
	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total
Jack Pine	3,440	1,450	4,890	10	--	10	3,450	1,450	4,900
Black Spruce	39,050	2,890	41,940	290	20	310	39,340	2,910	42,250
White Spruce	4,690	9,630	14,320	10	20	30	4,700	9,650	14,350
Balsam Fir	2,070	420	2,490	--	--	--	2,070	420	2,490
Tamarack Larch	160	30	190	--	--	--	160	30	190
Total Softwood	49,410	14,420	63,830	310	40	350	49,720	14,460	64,180
Trembling Aspen	14,060	4,420	18,480	10	--	10	14,070	4,420	18,490
Balsam Poplar	1,610	620	2,230	--	--	--	1,610	620	2,230
White Birch	2,110	300	2,410	--	--	--	2,110	300	2,410
Total Hardwood	17,780	5,340	23,120	10	--	10	17,790	5,340	23,130
Total	67,190	19,760	86,950	320	40	360	67,510	19,800	87,310

TABLE XII

Marine Transport Ltd.

Net Merchantable Volume

(in Cunits)

Species	Marine Transport								
	To 715' Contour			Channels			Total		
	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total
Jack Pine	1,110	420	1,530	10	20	30	1,120	440	1,560
Black Spruce	21,800	2,140	23,940	1,310	130	1,440	23,110	2,270	25,380
White Spruce	4,340	8,190	12,530	220	420	640	4,560	8,610	13,170
Balsam Fir	1,460	220	1,680	300	30	330	1,760	250	2,010
Tamarack Larch	90	10	100	10	--	10	100	10	110
Total Softwood	28,800	10,980	39,780	1,850	600	2,450	30,650	11,580	42,230
Trembling Aspen	6,810	2,350	9,160	210	120	330	7,020	2,470	9,490
Balsam Poplar	910	350	1,260	50	--	50	960	350	1,310
White Birch	1,500	260	1,760	80	10	90	1,580	270	1,850
Total Hardwood	9,220	2,960	12,180	340	130	470	9,560	3,090	12,650
Total	38,020	13,940	51,960	2,190	730	2,920	40,210	14,670	54,880

TABLE XIII

Net Merchantable Volume

(in Cunits)

Species	CFI			Marine Transport			Total		
	Total			Total			4"-9"	10"+	Total
	4"-9"	10"+	Total	4"-9"	10"+	Total			
Jack Pine	3,450	1,450	4,900	1,120	440	1,560	4,570	1,890	6,460
Black Spruce	39,340	2,910	42,250	23,110	2,270	25,380	62,450	5,180	67,630
White Spruce	4,700	9,650	14,350	4,560	8,610	13,170	9,260	18,260	27,520
Balsam Fir	2,070	420	2,490	1,760	250	2,010	3,830	670	4,500
Tamarack Larch	160	30	190	100	10	110	260	40	300
Total Softwood	49,720	14,460	64,180	30,650	11,580	42,230	80,370	26,040	106,410
Trembling Aspen	14,070	4,420	18,490	7,020	2,470	9,490	21,090	6,890	27,980
Balsam Poplar	1,610	620	2,230	960	350	1,310	2,570	970	3,540
White Birch	2,110	300	2,410	1,580	270	1,850	3,690	570	4,260
Total Hardwood	17,790	5,340	23,130	9,560	3,090	12,650	27,350	8,430	35,780
Total	67,510	19,800	87,310	40,210	14,670	54,880	107,720	34,470	142,190

Net Operable Volume

Net Operable Volume is determined by eliminating all trees in the 4-inch diameter class and all stands which contain less than 800 cubic feet per acres of the four major softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) in cutting classes 4 and 5 only. A summary of the Net Operable Volume to be lost in the Jen-Peg Project Area is given in Tables XIV, XV and XVI. Net Operable Volume represents the volume of the best forest stands in the area.

TABLE XIV

Churchill Forest Industries

Net Operable Volume To Be Lost*

(in Cunits - 100's of Cubic Feet)

Species	To 715' Contour				Channel				Total			
	5"	6"-9"	10"+	Total	5"	6"-9"	10"+	Total	5"	6"-9"	10"+	Total
Jack Pine	30	260	240	530	--	10	--	10	30	270	240	540
Black Spruce	2,830	9,160	1,500	13,490	40	120	10	170	2,870	9,280	1,510	13,660
White Spruce	220	2,110	6,930	9,260	--	--	--	--	220	2,110	6,930	9,260
Balsam Fir	220	910	220	1,350	--	--	--	--	220	910	220	1,350
Total	3,300	12,440	8,890	24,630	40	130	10	180	3,340	12,570	8,900	24,810

---

*This summary does not include the Net Operable Volume Summary of the Hardwoods Working Group.

TABLE XV

Marine Transport

Net Operable Volume To Be Lost*

(in Cunits - 100's of Cubic Feet)

Species	To 715' Contour				Channels				Total			
	5"	6"-9"	10"+	Total	5"	6"-9"	10"+	Total	5"	6"-9"	10"+	Total
Jack Pine	200	1,880	900	2,980	--	--	20	20	200	1,880	920	3,000
Black Spruce	1,760	5,840	1,250	8,850	10	70	60	140	1,770	5,910	1,310	8,990
White Spruce	350	2,570	6,780	9,700	10	150	370	530	360	2,720	7,150	10,230
Balsam Fir	180	680	110	970	70	180	30	280	250	860	140	1,250
Total	2,490	10,970	9,040	22,500	90	400	480	970	2,580	11,370	9,520	23,470

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*This summary does not include the Net Operable Volume Summary of the Hardwoods Working Group.

TABLE XVI

Total Net Operable Volume To Be Lost*

(in Cunits - 100's of Cubic Feet)

Species	Churchill Forest Industries				Marine [illegible]port				Total			
	5"	6"-9"	10"+	Total	5"	6"-9"	[illegible]	Total	5"	6"-9"	10"+	Total
Jack Pine	30	270	240	540	200	1,880	920	3,000	230	2,150	1,160	3,540
Black Spruce	2,870	9,280	1,510	13,660	1,770	5,910	1,310	8,990	4,640	15,190	2,820	22,650
White Spruce	220	2,110	6,930	9,260	360	2,720	7,150	10,230	580	4,830	14,080	19,490
Balsam Fir	220	910	220	1,350	250	860	140	1,250	470	1,770	360	2,600
Total	3,340	12,570	8,900	24,810	2,580	11,370	9,520	23,470	5,920	23,940	18,420	48,280

*This summary does not include the Net Operable Volume Summary of the Hardwood Working Group.

Effect on Annual Allowable Cut

Annual Allowable Cut calculations have been made for Forest Management Unit 82 and Forest Management Unit 83 in order to provide guidelines for species and volumes available for harvest on an annual basis as required for sustained yield (continuous wood supply) management.

Calculations made for Forest Management Unit 82 are the responsibility of the Forest Inventory Section and were completed March 20, 1972. Calculations made for Forest Management Unit 83 are the responsibility of Churchill Forest Industries (Manitoba) Limited and were submitted March 20, 1972 as part of the Management Plan for the first 50% of the Specified Area.

Calculations were made for each working group and in addition for each species. For examination purposes the Practical Annual Allowable Cut was selected, as this calculation gave the volume available for future disposition. In Forest Management Unit 82 a 12% reduction factor has been applied to calculated estimates to cover losses due to fire, new construction and withdrawals from commercial harvesting operations (i.e. recreation areas). In examination of Forest Management Unit 82, therefore, the critical level is a 12% or greater reduction in the annual allowable cut.

In Forest Management Unit 83 a 15% reduction factor has been applied by Churchill Forest Industries to calculated estimates to cover future losses. In examination of Forest Management Unit 83, therefore, the critical level is 15% or greater reduction in the annual allowable cut.

1) Forest Management Unit 82

Losses in two working groups were of sufficient extent to require examination. Black Spruce, Site I Working Group losses were numerically the largest, but recalculation indicates that only a 2% reduction in both area and volume available on an annual basis will result from construction and inundation. This is well within the 12% factor built into the calculations.

White Spruce Working Group losses, although numerically less, proved to be more important. Re-calculation indicates that a 9% reduction in both area and volume available annually will result from construction and inundation. This is within the 12% factor built into the calculations, but further development which may affect the White Spruce Working Group, such as recreation development or major fires could require a reduction in the White Spruce annual allowable cut.

2) Forest Management Unit 83

Losses in two working groups were of sufficient extent to require examination. Black Spruce, Site I Working Group losses were numerically the largest, but re-calculation indicates that only a 1% reduction in both area and volume available annually will result from construction and inundation. This is well within the 15% factor built into the calculations.

White Spruce Working Group losses, although numerically less, proved to be the most important. Re-calculation indicates that a 9% reduction in both area and volume available annually will result. This is within the 15% factor built into the calculations, but further development which could affect the White Spruce Working Group, such as recreation development or major fires could require a reduction in the White Spruce Annual Allowable Cut.

Timber Clearing

All trees within the area to be flooded, cleared for channels or covered by sediment will be killed. To minimize dollar losses as much as possible of the merchantable volume to be lost should be salvaged and utilized commercially.

The Project Area falls partly within Churchill Forest Industries (Manitoba) Limited's specified area. Present access to the area makes economical harvesting for delivery to The Pas doubtful, but new access routes could improve the situation.

Marine Transport Limited holds the option on the area in which the southern portion of the project area is located. This company has harvested saw timber in the project area in the past. In addition, pulpwood has been shipped from the Norway House area by barge to Abitibi (Manitoba) Paper Company at Pine Falls.

Areas to be cleared under contract with Manitoba Hydro will provide a supply of wood that has commercial value in the form of sawlogs and pulpwood. The cutting and disposal of this wood has been paid for in the clearing contracts. As these areas are immediately adjacent to the shoreline, barge transport South would appear to be economically feasible considering that loading and shipping would be the main costs incurred. There is a good market for spruce pulpwood at Pine Falls at this time.

For Forestry purposes alone widespread clearing of all trees on areas to be flooded is not necessary. Clearing, aside from utilizing the more valuable stands of trees, most of which are covered by present clearing contracts, should be carried out to provide shore access in critical areas. Critical areas would include future recreation sites, points of land where wind direction could force boat travellers to seek shelter, and high-use areas near hydro control structures.

Beneficial Effects

The principal beneficial effect of the Outlet Lakes project development on forestry will be the improvement in land accessibility (both summer and winter), assuming that a road will be constructed across the Jen-Peg Dam, and summer water accessibility. The roads that will be built to provide access to construction sites will provide access to presently inaccessible timber stands. As the general area produces timber of merchantable quality and constitutes part of the leasehold of existing forest industries, the improved accessibility will benefit future timber utilization in the area.

The dumping of debris from channel construction in low non-forested areas could provide more productive forest land in the future. The extent of improved areas for tree growth cannot be determined until dumping has been completed.

The increase in water level and construction of channels will provide better barge transportation in the project area through the elimination of strong currents in the Nelson River channel and a significant reduction in travel distance to reach the West Channel of the Nelson River and upper Kiskittogisu Lake.

Clearing operations which are associated with the development project should provide the opportunity to train local people in forest harvesting operations and the operation of heavy equipment associated with these activities. This should result in a trained labour source for future forest harvesting operations related to present local sawmilling and future industrial forest utilization.

Detrimental Effects

There will be a relatively small loss of productive forest land area. As forests are a renewable resource, the loss could be considered on a repetitive basis into the future. There will be a reduction in the annual allowable cut in the Forest Management Units involved in the study area, but this reduction will be within the 12% and 15% reduction limit set out in the Inventory Report and working plans affected.

The detrimental effect of effluent dumping with respect to forest volume losses will not be known until dumping has taken place and the extent of the damage can be measured. Trees, the roots of which have been buried by significant depths of additional debris (in excess of two feet), will be killed. Damage can be minimized by depositing sediment in non-forested depression areas where the deposits can be retained until stabilized without entering streams or lakes in the vicinity.

At the present time, water currents in the main outlet channels can cause hazardous winter ice conditions over the watercourse. As greater winter water flows are to be expected from the regulated system, the winter ice conditions will likely be more hazardous. Winter logging operations requiring channel crossings may be impossible. This could be a serious problem for winter forest operations, in the area East of the Nelson River (west channel) unless road accessibility will be possible across the proposed control structure at the Jen-Peg site.

Maximum water levels may have detrimental effects on adjacent forest cover including black spruce swamp areas. The impact of the effect is not known at this time and will be studied as a separate project.

Annual volumes and areas available for harvest of the White Spruce working group will decrease by 9% in the project area. This is within guidelines of 12% established in Forest Management Unit 82 and 15% established in Forest Management Unit 83. However, any additional losses through development or flooding in the White Spruce working group could cause the established guidelines to be exceeded. This would result in a decrease in available white spruce supply to woods operators in the project area.

VII. Conclusions

The effect of Hydro development on the Outlet lakes and West Channel of the Nelson River will cause losses in wood volume and forest area. These losses will not be of sufficient magnitude of decrease the annual allowable cut available to woods operators in the two Forest Management Units involved, unless greater flooding or increased clearing and development occurs in excess of the present project area limits.

A total of 22,928 acres or 35.8 square miles of land will be lost through the proposed development of the project area. Of the total area to be lost, 46.5% falls within the specified area of Churchill Forest Industries (Manitoba) Limited and the remaining 53.5% falls within the proposed option area of Marine Transport Limited.

Of the total area to be flooded, 52.7% is classified as productive or potentially productive forest land, with the remainder being Forested non-productive and non-forested land.

A total of 163,450 cunits of Gross Merchantable volume will be lost to flooding. This total volume consists of: Jack Pine 5%, Black Spruce 45%, White Spruce 18%, Balsam Fir 3% for a total Softwood component of 70%; and, Trembling Aspen 23%, Balsam Poplar 3%, White Birch 4%, for a total Hardwood component of 30%. This distribution of Gross Merchantable Volume by Diameter Class indicates that 73% of the Gross Merchantable volume falls in the 4"-9" diameter class and 27% in 10"+ diameter class.

The loss of net operable volume for softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) totals 48,280 cunits which consists of 5,920 cunits (12%) in the 5" diameter class (pulpwood), 23,940 cunits (50%) in the 6"-9" diameter class (small sawlogs and pulpwood) and 18,420 cunits (38%) in the 10"+ diameter class (sawlogs).

A major attempt should be made to utilize the wood volume to be lost due to flooding. The project area is totally within areas set aside for commercial timber operations as represented by Churchill Forest Industries and Marine Transport Limited.

A relatively large portion of the project area is being cleared under present Manitoba Hydro Contracts. If the commercial wood volume involved in these contract areas cannot be disposed of to established industries at a profit, there will be little, if any, opportunity for utilization of wood volumes in the more remote areas to be affected by Hydro development.

The effect of sediment deposition from channel construction cannot be ascertained at this time. It was not practical to calculate area and volume loss due to the confusion surrounding the area to be disturbed by effluent storage. Present licences covering the channels appear to assign disposal areas far in excess of what will be actually required to handle the sediment involved. As the proposed disposal area appears to be excessively large, volume losses for tree species would tend to be over-inflated giving a misleading concept of actual losses which may or may not result.

APPENDIX I

AREA REPORTS

One Copy Submitted to Study Director

APPENDIX II

VOLUME REPORTS

One Copy Submitted to Study Director

APPENDIX III

Photographs

Shoreline Kiskittogisu Lake - Black Spruce and Jack Pine combinations.

Low shoreline profile encountered along the Kiskittogisu River at the South end of Kiskittogisu Lake.

White Spruce forest cover on a small island north end of Kiskittogisu Lake.

Rapids along Nelson River exhibiting low shoreline profile with Black Spruce predominating.

APPENDIX IV

Glossary of Terms

Glossary

Brush and Shrub (815) - Areas of private and leased land only, cleared of tree cover for future agricultural use, temporarily covered with brush, shrubs, etc.

Barren-Bare Rock (800) - Tundra and rock with less than 25 percent tree cover.

Cover Type - Four broad cover types are recognized - Softwood "S", Softwood-Hardwood "M", Hardwood-Softwood "N", Hardwood "H". The first number of the type aggregate code indicates the cover type.

Code - 0-3 - Softwood - "S" - includes all stands where at least 76 percent of the total basal area consists of coniferous species.

4-7 - Softwood-Hardwood Mixedwood - "M" - includes all stands where the basal area of all the coniferous species is between 51 percent and 75 percent of the total basal area.

8 - Hardwood-Softwood Mixedwood - "N" - includes all stands where the basal area of all coniferous species is between 26 percent and 50 percent of the total basal area.

9 - Hardwood - "H" - includes all stands where the basal area of all coniferous species is less than 25 percent of the total basal area.

The above cover types are determined by the percent of basal area of softwood in proportion to the total basal area found on all plots taken within a stand.

Crown Closure - This is a stand density estimate made by a photointerpreter. Crown Closure is the percentage of the ground within a stand covered by the crowns of trees located within the stand. The following crown closure classes are recognized in Manitoba:

Forest Regions 1, 2, 4 and 5 and the Whiteshell

Code

0 - applies to potential productive stands only
1 - 15% to 30% crown closure
2 - 31% to 50% crown closure
3 - 51% to 70% crown closure
4 - 71% and over

Forest Regions 3, 6, 7, 8 and 9 excluding the Whiteshell

Code

0 - 0 to 20% crown closure
2 - 21 to 50% crown closure
3 - 51 to 70% crown closure
4 - 71% and over

Cull Factors - Percentage reduction factors by diameter group applied to Gross Merchantable Volume to obtain Net Merchantable Volume. The factors are based on expected and known losses due to decay, damage and shape by species and diameter group. The following factors apply to Forest Regions 3, 5, 6, 7, 8 and 9.

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black Spruce	5%	10%
White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
Hardwoods	20%	40%

Cutting Class - This is a designation applied to forest stands based on size, vigour, state of development and maturity of a stand for harvesting purposes. Five cutting classes are recognized as follows:

Cutting Class 0 - Forest land not restocked following fire, cutting, windfall, or other major disturbances (hence, potentially productive land). Some reproduction or scattered residual trees (with net merchantable volume less than 2.5 cunits per acre may be present).

Cutting Class 1 - Stands which have been restocked either naturally or artificially. There may be scattered residual trees present as in Cutting Class 0. To be in Cutting Class 1, the average height of the stand must be less than 12 feet.

Cutting Class 2 - Advanced young growth of post size, with some merchantable volume. The average height of the stand must be over 12 feet in order to be in this cutting class.

Cutting Class 3 - Immature stands with merchantable volume growing at or near their maximum rate, which definitely should not be cut. The average height of the stand should be over 25 feet and the average diameter should be over 3.6 inches at D.b.h.

Cutting Class 4 - Mature stands which may be cut as they have reached rotation age (± 10 years or ± 20 years on Site 2 black spruce, tamarack larch and eastern cedar).

Cutting Class 5 - Overmature stands which should be given priority in cutting due to susceptability to decay, natural damage and insect attack.

Diameter Breast Height (D.b.h.) - The diameter of a tree measured at breast height (4.5 feet above ground level). Measurement at this point gives a diameter free from butt swell and is a convenient standard point for measurement. Volume estimates are based on diameter at breast height.

Fields (Agriculture) (810) - Areas of private and leased land cleared of tree cover and presently under an agricultural use.

Forest Management Unit - The Forest Management Unit is the basic unit of area considered for Forest Inventory purposes. Forest Management Units have been established on a variety of situations including: status and ownership, administrative units, accessibility, acceptable size and/or forest cover variations.

Forest Regions - There are 9 Forest Regions in the Forest Zone of the Province of Manitoba. Forest Regions have been established based on physical geography and administrative boundaries. Each Forest Region has been further subdivided into Forest Management Units as follows:

1 - Mountain Forest Region - Forest Management Units 11-15

2 - South East Forest Region - Forest Management Units 20-29

3 - Lake Winnipeg East Forest Region - Forest Management Units 30-39

4 - Lowland South Forest Region - Forest Management Units 40-49

5 - Lowland North Forest Region - Forest Management Units 51-57

6 - Northern Mining Forest Region - Forest Management Units 60-66

7 - Northern Transition Forest Region - Forest Management Units 71-75

8 - Nelson River Forest Region - Forest Management Units 81-89

9 - North East Forest Region - Forest Management Units 90-99

0 - Agriculture - Units 01-09

Forest Zone - The Forest Zone is the area which is producing or capable of producing forest crops and which for climatic reasons, is in the main, more suitable for the production of forests than for agricultural crops. The definition of the Forest Zone boundary is essentially the same as the definition of the Wooded District Boundary as presented in "The Fires Prevention Act" of the Province of Manitoba (R.S.M. 1954, Chapter 86).

Gross Merchantable Volume - This is the volume of all species with diameters 3.6" D.b.h. and larger and is found to a specified top diameter and a stump height of one foot. For spruce and pine, top diameter is 3"; for all other species, it is four inches. Volume only in Cutting Classes 3, 4 and 5 is considered.

Increment - annual or periodic increase in volume of a tree or a stand.

Ingrowth - increase of the merchantable volume of a stand as the result of non-merchantable trees (less than 3.5 inches D.b.h.) becoming merchantable during a period of time under consideration.

Marsh-Muskeg (830) - Marsh - Wet lands completely or partially covered with tall grass, rushes or sedges, unsuitable for hay, but can be used as a habitat for fur-bearing animals.

Muskeg - Wet land which has a vegetative cover consisting mainly of sphagnum moss and heath plants with very scattered brush. Black spruce, tamarack or cedar cover does not exceed 25%.

Mud and salt flats around lakes.

Meadow (820) - Moist to wet grassland suitable for hay production (natural hay land).

Mean Annual Increment - The total volume increment up to a given age divided by the age.

Merchantable Volume - The volume of the portion of a tree without bark, excluding the stump (12 inches high) and the top with the bottom diameter of 3 inches inside bark. Merchantable volume of a stand is the sum of the merchantable volume of all trees found in a stand.

Net Merchantable Volume - The Gross Merchantable Volume of all species with diameters 3.6" D.b.h. and larger less the respective cull factors. See Cull Factors.

Net Operable Volume - The Net Merchantable Volume of all operable stands. An operable stand is one which contains a minimum of 800 or greater cubic feet per acre in Cutting Classes 4 and 5 only of the four major Softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) excluding trees 4" D.b.h.

Non-Forested Land - Includes areas a) withdrawn from timber production for a long period of time, such as cultivated fields, hay meadows, pastures, settlements, rights-of-way, gravel pits, beaches, wide ditches, summer resorts, and b) not capable of producing merchantable timber, such as rock, barren, mines, marsh and muskeg.

Non-Productive Forested Land - Includes all forest land not capable of producing merchantable timber due to very low productivity.

Option Area - The area under examination in an Option Licence.

Option Licence - The Minister, with the approval of the Lieutenant-Governor-in-Council and after giving public notice, may issue an option licence to a forest industry for a forest area for a period not exceeding two years in order that the person to whom such a licence is issued may have an opportunity to make examinations and surveys to determine whether or not he wishes to obtain a forest management licence for all or part of such area, and the minister may forbid or restrict the issuance of any other timber licence or permit in the area covered by the Option Licence.

Ownership - The following ownerships of land within the Province of Manitoba are recognized:

Provincial Crown Land - Closed to forest operations	0
Provincial Crown Land - Open to forest operations	1
Provincial Crown - Restricted to forest operations	2
Federal Crown Land	3
Patented (Private) Land	5
Local Government District Land	6
Indian Reserve	7
Other	9

Potential Productive Forest Land - Includes forest land capable of producing merchantable timber, cut temporarily not producing, such as recent burn, clear-cut, or windstorm.

Practical Annual Allowable Cut - This is the amount of timber, by volume or area, based on net operable volume and area that can be cut each year on a sustained yield basis. A 12% reduction is made to all volumes as an allowance for no-cut zones, small scattered stands and fire losses.

Productive Forested Land - Includes all forest land capable of producing merchantable wood within rotation age regardless of its existing stage of productivity.

Productivity - The following diagram indicates the productivity breakdown:

Code

- TOTAL AREA
  - Land (1-899)
    - Forested (1-799)
      - Productive (1-699)
        - Softwood: 'S' (01-39)
        - Softwood-Hardwood Mixedwood: 'M' (40-79)
        - Hardwood-Softwood Mixedwood: 'N' (80-89)
        - Hardwood: 'H' (90-99)
      - Non-Productive (700-799)
        - Treed Muskeg (700)
        - Treed Rock (710)
        - Willow/Alder (720)
        - Protection Forest (730)
    - Non-Forested (800-899)
      - Barren-Bare Rock (800)
      - Fields (Agriculture) (810)
      - Brush & shrub on cleared patent land (815)
      - Meadow (820)
      - Marsh-Muskeg (830)
      - Unclassified (840)
  - Water (900)

Specified Area - All lands (less exceptions) owned by the Province within an area in Northern Manitoba effective April 1, 1966 as defined on Page 3 of the Memorandum of Agreement entered into on February 24, 1966 between the Province of Manitoba and Churchill Forest Industries (Manitoba) Limited. The forests located on the lands so defined were set aside to assure the required wood supply for the forest complex at The Pas, Manitoba.

Status - The term 'status of land' is used to indicate present or proposed committments on the following basis:

Status of Land	Code
Agricultural Zone	0
Provincial Forest	1
Proposed Permanent Forest	2
Licence Berths	4
Pulpwood Berths	5
Specified Areas - Timber Berths	6
Provincial Park	7
INCO Land	8
Agricultural land within the wooded area	9

Subtype - This term indicates the species composition in broad groups within the cover type. Subtype is determined by the proportion of basal area of two or three main species in the stand as found on a sample plot to the total basal area of all species. To determine the subtype, the basal area of indiviual species must be computed and rounded off to the nearest one percent.

Theoretical Annual Allowable Cut - This is the amount of timber, either by volume or area, based on net merchantable volume that can be cut each year on a sustained yield basis.

Treed Muskeg (700) - This is similar to open muskeg, except that the area is supporting semi-stagnated or stagnated trees. Some of the trees may produce "Christmas" trees or fence posts, but will not produce pulpwood size trees or fence posts within a rotation age of 140 years (4"+ D.b.h., height over 30 feet and 2.5 cords of net merchantable volume per acre). At least 26% of the area will be tree-covered.

Treed Rock (710) - Rock with a very shallow soil, supporting semi-stagnated or stagnated trees. At least 26 percent of the area will be tree-covered. These sites do not produce merchantable stands.

Type Aggregate - This term is used in reference to all stands or potentially productive areas in a Management Unit or Forest Section which have common characteristics as to cover type, subtype, site, cutting class, and crown closure.

Unclassified (840) - Rights-of-way, roads, gravel pits, beaches, summer resorts, mines, etc.

Water (900) - Includes lakes and rivers, measured at the high-water mark, able to be delineated on the aerial photographs. Narrow rivers and creeks are not to be considered as separate types, nor as type boundaries.

Willow/Alder (720) -	Low-lying areas with a saturated water table presently supporting willow or alder growth. Without improvement these sites are not capable of producing merchantable timber stands.
Working Group -	This term is used in reference to all stands or potentially productive areas on the same site and with the same predominant species.

APPENDIX 3 - C

FOREST RESOURCE INVENTORY OF THE AREA FROM THE INTERSECTION OF THE DIVERSION CHANNEL AND SOUTHERN INDIAN LAKE TO THE NOTIGI CONTROL SITE UP TO THE 850-FOOT ELEVATION CONTOUR

FOREST RESOURCE INVENTORY OF THE AREA FROM THE INTERSECTION OF THE DIVERSION CHANNEL AND SOUTHERN INDIAN LAKE TO THE NOTIGI CONTROL SITE UP TO THE 850-FOOT ELEVATION CONTOUR

by

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January, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

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SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

ABSTRACT

An estimated total land area lost of 101,484 acres and Gross Merchantable Volume of 294,650 cunits will be lost in the Rat River watershed due to flooding by the Churchill River Diversion Project. Brief descriptions of forest cover in the study area and survey methods are given. A detailed examination of land area and wood volume to be lost is given based on status of land. The chief detrimental effect, loss of 2.6 percent of the productive forest land in the Forest Management Units involved, will be partly offset by improved access to the area during development of the hydro project.

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SUMMARY

I. Recommendations

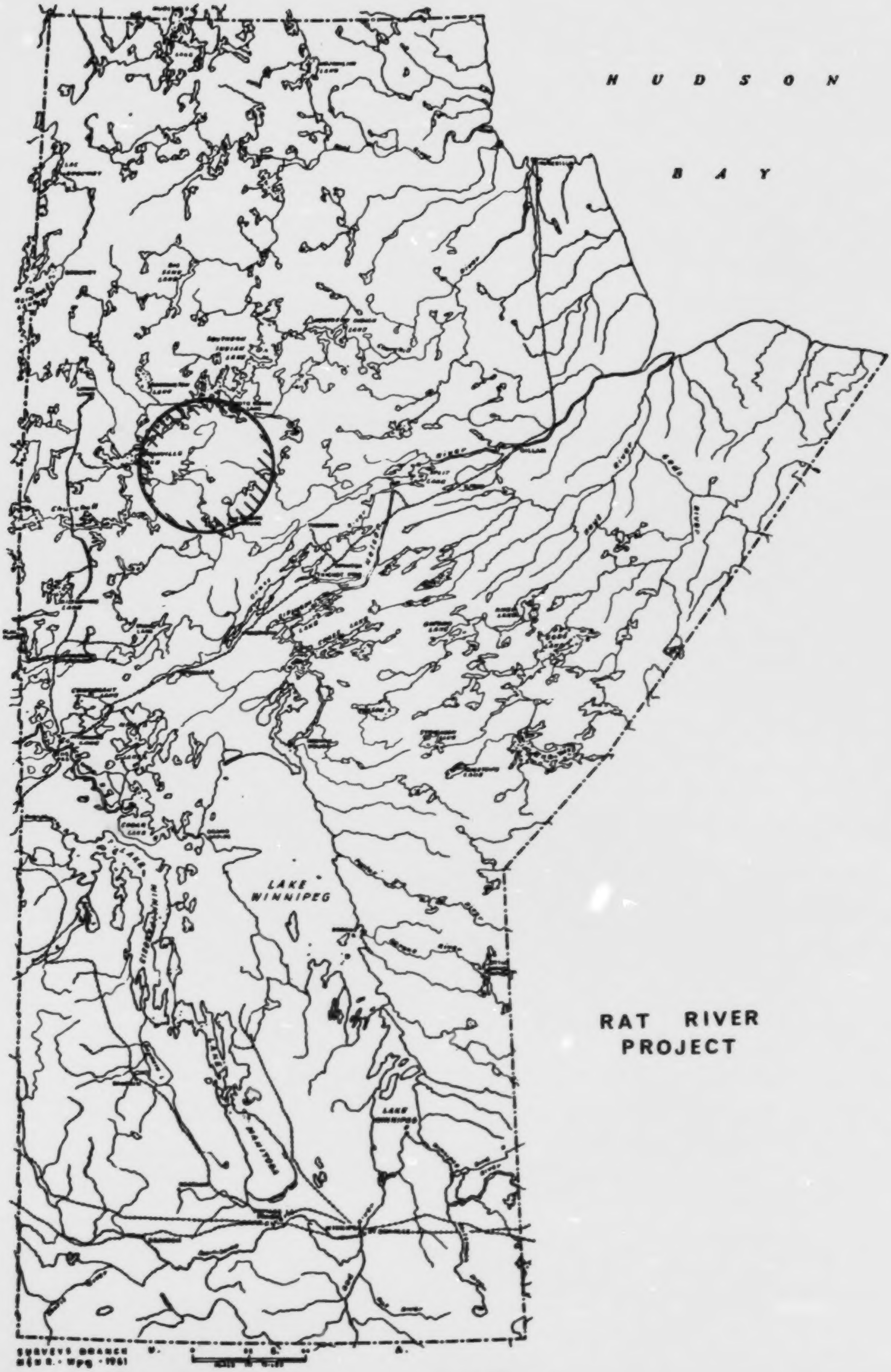
Though the southern part of the Project Area is within the Churchill Forest Industries (Manitoba) Limited Specified Area, it must still be considered remote. This makes harvesting at best an economically marginal operation, but one that must be considered. In critical areas where clearing is essential, clearing with salvage may be less costly than clearing by piling and burning without utilization.

II. Objectives

The objectives are to describe the forest cover, to determine area and volume losses, and to assess the implications of these losses in the Forest Management Units involved.

III. Terms of Reference

The study will give the area and volume to be lost through flooding in the Project Area plus an examination of expected beneficial and detrimental effects. Total area to be affected by flooding is given plus an area classification regarding forest productivity. Merchantable volume for all species, for softwood species, and for operable softwood stands is included.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LAKE WINNIPEG
LAKE MANITOBA
LAKE WINNIPEGOSIS
SURVEYS BRANCH
1961

RAT RIVER
PROJECT

IV. Study Area

The study area covered by this report includes the Rat River Watershed from Notigi Lake to the headwaters plus that area from the headwaters to South Bay via Isset Lake in which a connecting channel will be located.

All lands in the study area are Provincial Crown Lands. Of the total land area to be lost in the project area, 60.6% or 96.0 square miles falls within the Specified Area of Churchill Forest Industries (Manitoba) Limited, and 39.4% or 62.5 square miles falls within the uncommitted Proposed Permanent Forest area.

V. Methodology

Land areas and forest volumes were classified, measured and analyzed on the basis of standard forest inventory procedures used by the Province of Manitoba. The area to be flooded was determined by superimposing the 850-foot contour line on 4"=1 mile forest cover maps in Forest Management Unit 66 and on 2"=1 mile forest cover maps in Forest Management Units 72 and 73. The forest cover maps were produced by Forest Inventory and the contour line was superimposed by Manitoba Hydro personnel.

VI. Observations

The total area to be lost through flooding is 101,484 acres or 158.5 square miles.

The productive forest area to be lost will be 48,954 acres (76.5 square miles) or 48.3% of the total land area.

The total Gross Merchantable Volume of all species to be lost is estimated to be 294,650 cunits.

The total Net Merchantable Volume of all species to be lost is estimated to be 251,170 cunits.

The total Net Merchantable Volume of Softwood species only, is estimated to be 156,490 cunits.

The total Net Operable Volume of the four major softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) is estimated to be 21,890 cunits.

Beneficial effects are related primarily to improved forest access due to road development.

The main detrimental effect is a 2.6 percent loss of productive forest land in the Forest Management Units involved. Some degradation of additional productive forest sites is probable due to disrupted drainage patterns.

VII. Conclusions

The Churchill River Diversion Project will cause losses in Gross Merchantable wood volume of 294,650 cunits and an area loss of 101,484 acres in the Rat River Watershed.

The loss of Net Operable Volume of the four major Softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) consists of 4,480 cunits (20%) in the 5" diameter class, 14,400 cunits (66%) in the 6"-9" diameter class and 3,010 cunits (14%) in the 10"+ diameter class for a total of 21,890 cunits.

Harvest appears to be only marginally economical in most of the Project Area. Clearing must be executed in specific critical areas. Harvest should be considered in these areas and in operable stands.

Timber Clearing and Salvage Study
# of the
Rat River Watershed

I. Recommendations

The loss of wood volume or land area in the Rat River Watershed due to the Churchill River Diversion Project, if the sole criterion for the land value is its forest productivity, is not sufficient to warrant hindrance of the Project. Commercial harvest under present market and accessibility conditions is only marginally economical. Loss in annual allowable cut volumes would be relatively insignificant.

In spite of its being a cost liability, other factors necessitate some form of removal. In "Memorandum on Clearing - Southern Indian Lake, Rat-Notigi Reservoir" (August, 1972), F. F. Slaney indicates areas in which clearing is necessary in a project of this type and relates this to the Churchill Diversion Project. The consensus is that clearing is essential in the areas that will be most used in the first decade after flooding. This includes areas surrounding settlements, damsites, navigation routes, major new channels, and sport and commercial fishing areas. Applied to the Churchill River Diversion, these criteria demand a comprehensive clearing program in the Rat River Watershed. It is through the Rat River Valley that the water will be diverted from the lower Churchill River. The Rat River will be greatly increased in volume and will have a substantial current. Though there are no present settlements on the Rat River, it will provide a navigable route to South Indian Lake Settlement from the Thompson-Lynn Lake Highway at the Notigi Dam Site. The main water route to South Bay will continue to be from Leaf Rapids through Opachuanau and Southern Indian Lakes. A road is to be extended from the present Ruttan Lake mine site to the head of the channel at South Bay. Even if this road is not continued to South Indian Lake Settlement, most local people would probably use the road or the shorter water route to Leaf Rapids rather than the Rat River route. Fish population is expected to increase in this area because of the increased nutrient flow caused by the Diversion. Therefore, the Rat River will be traversed most frequently by sport and commercial fishermen. Clearing and disposal of debris is necessary to:

1) prevent damage to the Notigi Dam,
2) eliminate as much as possible the hazard of flotsam and deadheads to navigation,
3) minimize difficulty to sport and commercial fishing, and
4) prevent large tracts of unsightly dead trees in this travelled region.

Four clearing methods are described in the Slaney report. These are:

1) felling with floatage control,
2) felling and burning,
3) piling and reasonably complete burning, and
4) cutting and disposal after flooding.

The situation in the Rat River System apparently would be best met by a combination of the first three methods. Cutting and disposal after flooding is advantageous only where it can be postponed until its operational cost, two to three times that of surface clearing according to Slaney, is more than offset by interest charged on the cost of pre-flood clearing during the period of time between clearing and power production. In the crucial area of the Notigi Dam Site, felling and burning is recommended, but felling only has been suggested in the rest of the area. From a resource operations aspect, all material felled, but not salvaged, should be piled and burned to minimize future problems caused by debris. Manitoba Hydro has proposed a swath be cut from South Bay to the Notigi Dam Site. This would involve an area of 101,484 acres. Control of flotsam is necessary, particularly around the dam site and in narrow sections of the channel. In these areas floating debris may have to be removed from the water. In the rest of the Rat River region, sufficient control should be possible through booming this material in backwater until it sinks. Adequate boom logs should be available in the area. Slaney says some local material might be used in construction during the Project. Installation of one or more portable sawmills, at Leaf Rapids or the Notigi Dam Site, may be a viable proposition. Consideration should be given to the economics of the problem soon in order to have an operable plan in time for the construction work.

II. Objectives

The object of the study is to determine the area, volume, timber type and merchantability of timber which will be affected by inundation in the Rat River Watershed upon completion of the Churchill River Diversion Project.

III. Terms of Reference

For purposes of the study it has been considered that all timber stands below the high-water contour will be affected. Data has been compiled to give the following pertinent information for this area:

1) total area to be affected by flooding
2) area classification regarding forest productivity
3) merchantable volume, all species
4) merchantable volume, softwood species
5) merchantable volume of operable softwood stands
6) examination of beneficial effects
7) examination of detrimental effects

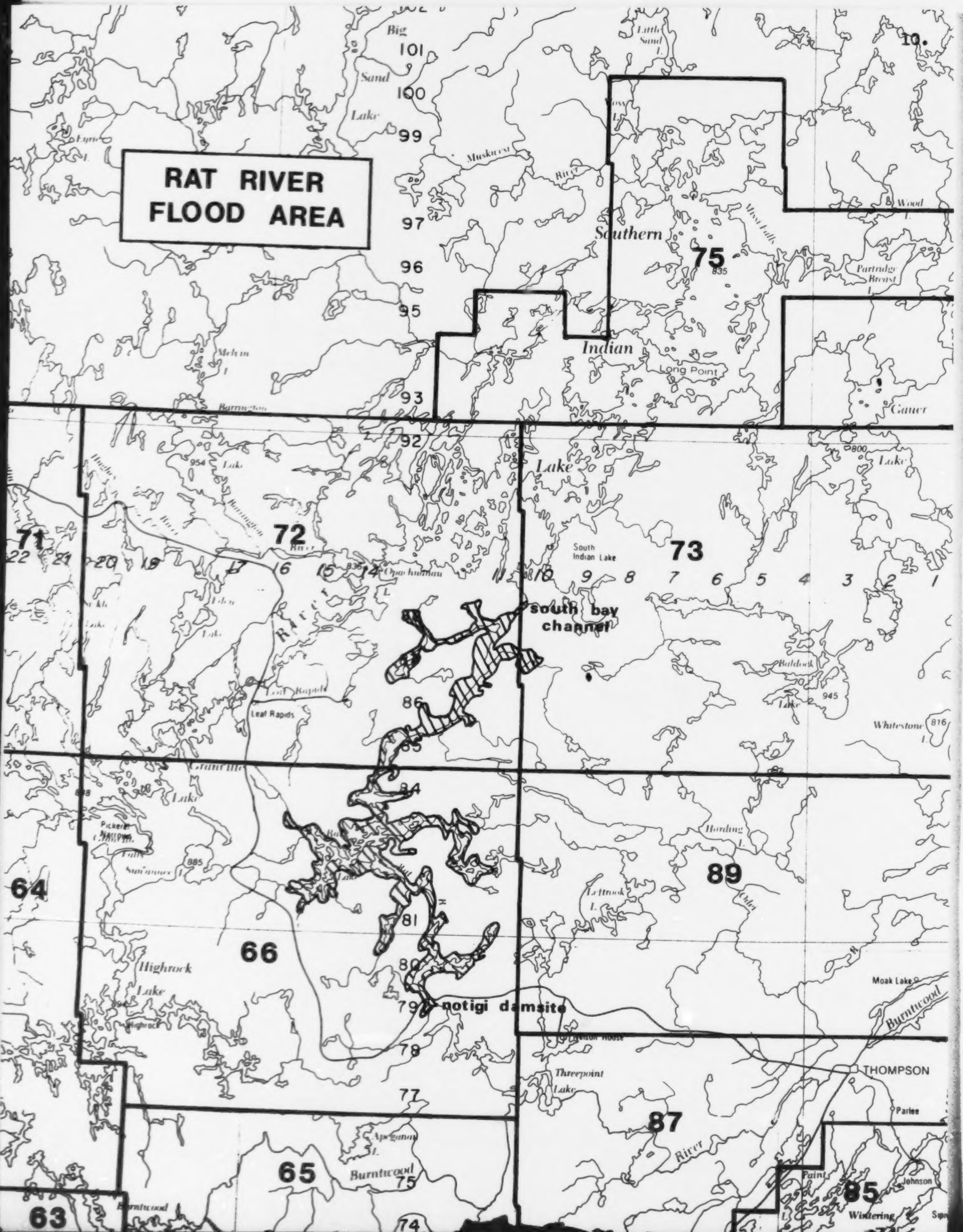
IV. Study Area

The area to be considered is that lying between South Bay on Southern Indian Lake and the Notigi Lake control structure on the Rat River. This includes a channel from South Bay to the headwaters of the Rat River plus the river system itself downstream to the Notigi damsite.

Location and Status

The study area falls in Forest Management Units 66, 72 and 73. The forest area and volume in Management Unit 66 is committed to Churchill Forest Industries (Manitoba) Limited, while that in Management Units 72 and 73 is uncommitted Proposed Permanent Forest. No ownerships other than Provincial Crown Lands are within the Project Area.

RAT RIVER FLOOD AREA


Big Sand Lake
101
100
99
97
96
95
93
92
86
85
84
81
80
79
78
77
75
74
Little Sand L.
10
Eyre L.
Muskwest River
Southern Indian Lake
75
835
Long Point
Partridge Breast L.
Wood L.
Gauer
Melvin L.
Barrington
954
Lake
72
71
Barrington River
Rat River
22 21 20 19 17 16 15 14
836
Opachuanau L.
11 10 9 8 7 6 5 4 3 2 1
South Indian Lake
73
south bay channel
800
Lake
Baldock Lake
945
Whitestone L.
816
Leaf Rapids
Granville Lake
898
Pickerel Narrows
Suwannee
885
64
66
Harding L.
89
Lettrook L.
Highrock Lake
Highrock
notigi damsite
Moak Lake
Burntwood
THOMPSON
Paint
Threepoint Lake
87
River
Parlee
65
Apeganau L.
Burntwood
Burntwood
63
85
Johnson
Wintering

V. Methodology

A recent, complete Forest Resource Inventory of the Project Area is available. Aerial photography of the area was flown in 1969. The photography for that portion of the area in Management Unit 66 is at a scale of four inches to one mile (1:15,840), while that in Management Units 72 and 73 is at a scale of two inches to one mile (1:31,680). The field survey was made in the 1971 season by the Forest Resource Inventory Section and compilation of the data was completed in October, 1972.

A summary is presented here to outline the inventory system. Complete details of the method of field survey and descriptions of the classification system used are presented in the field cruising manual prepared by the Forest Resource Inventory Section.

Section corners and preliminary typing of the forest stand boundaries were delineated on aerial photographs. Forest types are based on species composition, site, cutting class (maturity) and crown closure (density). Base maps were prepared at a scale of four inches to one mile for the area in Management Unit 66 and at a scale of two inches to one mile for the portion in Management Units 72 and 73. These maps were based on ground control established by the Surveys Branch. Detail from the aerial photographs was transferred by sketchmaster to the base maps. The forest cover so delineated was identified by number on a Township basis and photointerpreted.

Prism sample plots were established in a variable percentage of the stands identified on the aerial photographs. All species of trees counted in the sample plot were measured for height and diameter at breast height (D.b.h.). In addition the age of one or more trees on each plot was counted to give an age of the stand. Volume per acre estimates were prepared based on the field measurements.

Areas in acres for all stands delineated were determined and the volumes per acre were applied from the appropriate stand/stock volume table giving the expanded wood volumes for the area under consideration.

As a result, all type aggregates of cutting class 3 (lowest classification with recognized volume) and higher are based on volumes determined from variable numbers of sample plots which have been measured in the area and which have been located in stands having as similar characteristics as could possibly be determined.

Lands presently not restocked were classified as to site and the most suitable species which the site could support so that possible reforestation programs could be developed for specific areas or the Forest Management Unit as a whole.

Reduced copies of the original forest inventory maps at a scale of one inch to one mile have been prepared for each township in the Forest Management Units as a final step.

Aerial photomosaics were prepared at the original scale, either four or two inches to the mile, and are stored at the Regional Office at The Pas. Copies, reduced when necessary, were made at a scale of two inches to one mile and copies are stored at The Pas and at the Forest Inventory office in Winnipeg.

The 850' contour line was transferred to forest inventory maps at a scale of four inches to one mile in Management Unit 66 and two inches to one mile in Management Units 72 and 73. Area of land to be lost was calculated. Wood volumes involved were determined by applying the productive areas to be lost in acres against the stand/stock volume tables covering the Forest Management Units involved.

Stand/Stock Volume Tables

Two stand/stock volume tables are used to provide estimates of volume for the project area. The first volume table was developed for Forest Management Units 60 through 66 which fall within the Specified Area of Churchill Forest Industries (Manitoba) Limited. The volume table is based on trees measured on 12,897 sample plots located throughout the seven Management Units.

The second stand/stock volume table was developed for Forest Management Units 71, 72 and 73 which lie in an area of Proposed Permanent Forest. It is based on trees measured on 2,705 sample plots located throughout these three Management Units.

Rotation Period

Rotation periods used for the Forest Management Units within which the Project Area falls were determined on the basis of present market conditions for the various species, the size and type of products for which the species are most suited, and the growth rate of these species in the area.

For Management Unit 66 the following rotation ages apply to the various working groups:

Jack Pine, All Sites - 80 Years
Black Spruce, Site I - 80 Years
Black Spruce, Sites II & III - 140 Years
White Spruce, All Sites - 100 Years
Balsam Fir, All Sites - 80 Years
Tamarack Larch, All Sites - 140 Years
Hardwoods, All Sites - 80 Years

For Management Units 72 and 73, these rotation ages apply to the various working groups:

Jack Pine, All Sites	- 80 Years
Black Spruce, Site I	- 100 Years
Black Spruce, Sites II & III	- 140 Years
White Spruce, All Sites	- 100 Years
Hardwood, All Sites	- 80 Years

For reference purposes, the following Age Distribution by Cutting Classes are provided for each working group encountered in the Project Area. This gives the approximate age range in years for each cutting class of each working group.

TABLE I

Age Distribution in Years by Cutting Classes and Working Groups

Management Unit 66

Working Group	Cutting Class				
	1	2	3	4	5
Jack Pine, All Sites	1-10	11-25	26-70	71-90	91+
Black Spruce, Site I	1-15	16-30	31-90	91-110	111+
Black Spruce, Sites II & III	1-30	31-75	76-120	121-160	161+
White Spruce, All Sites	1-20	21-30	31-90	91-110	111+
Balsam Fir, All Sites	1-10	11-25	26-70	71-90	91+
Tamarack Larch, All Sites	1-25	26-70	71-120	121-160	161+
Hardwoods, All Sites	1-15	16-30	31-70	71-90	91+

TABLE II

Age Distribution in Years by Cutting Classes and Working Groups

Management Units 72 and 73

Working Group	Cutting Class				
	1	2	3	4	5
Jack Pine, All Sites	1-10	11-25	26-70	71-90	91+
Black Spruce, Site I	1-15	16-35	36-80	81-120	121+
Black Spruce, Sites II & III	1-30	31-75	76-120	121-160	161+
White Spruce, All Sites	1-20	21-30	31-90	91-110	111+
Hardwood, All Sites	1-15	16-30	31-70	71-90	91+

VI. Observations

Forest Description

Rowe's[1] placement of the major forest zones of Canada puts the bulk of the Rat River System in the Nelson River Section and the Northern Coniferous Section of the Boreal Forest Region with the area from the headwaters of the Rat River to South Bay in the Northwestern Transition Section. Forest Inventory data collected in 1971 shows tree growth to be better around South Bay than indicated by Rowe's classification. That is, the Northwestern Transition Section actually does not extend far enough south to include any of the Rat River System.

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[1] Forest Regions of Canada - J. S. Rowe
Canada Department of Northern Affairs and National Resources
Forestry Branch - Bulletin 123

Tree species in the Northern Coniferous Section and the adjacent Nelson River Section are identical in the Rat River Watershed. Soils are slightly better in the latter with correspondingly improved tree growth.

The tree species found in the Rat River Watershed are black spruce (*Picea mariana*), white spruce (*Picea glauca*), jack pine (*Pinus banksiana*), balsam fir (*Abies balsamea*), tamarack (*Larix laricina*), trembling aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*) and white birch (*Betula papyrifera*). Of these species only black spruce, white spruce and jack pine are of major commercial importance in the Study Area at this time. Neither tamarack nor any of the hardwood species is currently harvested, except on a local scale as firewood. This being one of the most remote and inaccessible forested regions of Manitoba, even normally merchantable species have been limited to use by the small local populace for construction and fuel.

Table III is presented to summarize the characteristics of the various forest working groups encountered in the Project Area.

TABLE III

Characteristics of Working Groups Found in Rat River Project Area

Working Group	Site	Tree Cover		Rotation (Years)	D.b.h. Range at Maturity (inches)	Height Range at Maturity (feet)	Gross Merchantable Volume per Acre at Maturity (All Species) cunits per acre	Landform	Soil Moisture	Drainage
		Primary Species	Associate Species							
Jack Pine	1	Jack Pine	Black Spruce Trembling Aspen White Birch	80	6 to 15	55 to 70	17 to 22	Slopes, intermediate terraces and small rock outcrops	Fresh to moist	Good
Black Spruce	1	Black Spruce	White Spruce Trembling Aspen Jack Pine	80	6 to 14	45 to 65	12 to 19	Low glacial till ridges and lacustrine flats	Moist to wet	Good
Black Spruce	2	Black Spruce	Tamarack Larch Balsam Poplar	140	4 to 8	30 to 45	7 to 12	Flat, deep organic terrain	Wet to saturated	Insufficient
Black Spruce	3	Black Spruce	Jack Pine Trembling Aspen Balsam Poplar White Birch	140	4 to 8	30 to 45	7 to 14	Associated with rock outcrops	Fresh to dry	Excessive
White Spruce	1	White Spruce	Trembling Aspen Balsam Fir Black Spruce White Birch	100	10 to 25	55 to 85	30 to 45	Lacustrine flats immediately adjacent to rivers and lakes	Moist to fresh	Good
Balsam Fir	1	Balsam Fir	White Spruce Black Spruce Trembling Aspen Balsam Poplar White Birch	80	6 to 15	45 to 65	15 to 20	Lacustrine flats immediately adjacent to rivers and lakes	Moist to fresh	Good
Tamarack	1 & 2	Tamarack	Black Spruce White Birch	140	4 to 9	30 to 45	0 to 1	Low, spring-fed lacustrine flats; organic flats	Wet to saturated	Adequate to insufficient
Hardwood	1	Trembling Aspen Balsam Poplar White Birch	White Spruce Black Spruce Balsam Fir Jack Pine	80	8 to 20	55 to 75	15 to 20	Slopes & intermediate terraces, lacustrine flats	Fresh to very moist	Good

Area to be Lost by Flooding

The area to be lost through flooding to the 850' contour has been calculated to be 101,484 acres or 158.5 square miles. The total area involved has been summarized and is presented in Tables IV and V. A detailed breakdown of productive forest area only is presented in the following section under Tables VI, VII and VIII.

Statistical reports covering the project area calculations as produced by computer are presented with the original report only, under separate cover as Appendix I.

Table IV gives the area to be lost due to flooding by Township and Range.

TABLE IV

Area to be Flooded by Ownership and Status of Land

(in Acres)

Township	CFI Specified Area	Proposed Provincial Forest	Total Area to be Flooded in Rat River Watershed
	Provincial Crown (61)	Provincial Crown (21)	
79-12 W	402	--	402
-13	5,013	--	5,013
80-11 W	664	--	664
-12	3,234	--	3,234
-13	4,140	--	4,140
-14	362	--	362
81-11 W	1,227	--	1,227
-12	726	--	726
-13	1,721	--	1,721
-14	569	--	569
-15	1,193	--	1,193
-16	297	--	297
82-11 W	744	--	744
-12	1,770	--	1,770
-13	4,557	--	4,557
-14	3,668	--	3,668
-15	4,715	--	4,715
-16	625	--	625
83-11 W	557	--	557
-12	4,359	--	4,359
-13	4,511	--	4,511
-14	7,999	--	7,999
-15	2,237	--	2,237
84-12 W	615	--	615
-13	1,605	--	1,605
-14	3,955	--	3,955
85-12 W	--	2,074	2,074
-13	--	4,916	4,916
-14	--	1,203	1,203
86-12 W	--	5,888	5,888
-13	--	2,452	2,452
87-10 W	--	2,226	2,226
-11	--	8,188	8,188
-12	--	1,381	1,381
-13	--	2,816	2,816
88-10 W	--	6,196	6,196
-11	--	82	82
-12	--	967	967
-13	--	1,630	1,630
Total Area	61,465	40,019	101,484
Square Miles	96.04	62.53	158.57
Percent	60.60	39.40	100.00

TABLE V

Area to be Lost Through Flooding by Productivity and Status of Land

(in Acres)

Type	CFI	Proposed Permanent Forest	Total Area to be Flooded	%	%
	Provincial Crown (61)	Provincial Crown (21)		Productivity	Total Area
Jack Pine, All Sites	5,418	832	6,250	12.8	
Black Spruce, Site I	10,496	5,517	16,013	32.7	
Black Spruce, Sites II & III	2,919	--	2,919	6.0	
White Spruce, All Sites	23	--	23	--	
Total Softwoods	18,856	6,349	25,205	51.5	--
Hardwoods	13,042	2,133	15,175	31.0	--
Total Forested Productive	31,898	8,482	40,380	82.5	--
c.c.o. Jack Pine	1,397	39	1,436	2.9	
c.c.o. Black Spruce, Site I	3,111	589	3,700	7.6	
c.c.o. Black Spruce Sites II & III	3,438	--	3,348	7.0	
Total Potential Productive	7,946	628	8,574	17.5	--
Total Productive	39,844	9,110	48,954	100.0	48.3

TABLE V (Cont'd)

Type	CFI	Proposed Permanent Forest	Total Area to be Flooded	% Productivity	% Total Area
	Provincial Crown (21) 61	Provincial Crown (61) 21			
Treed Muskeg (700)	12,895	25,538	38,433		37.9
Treed Rock (710)	662	--	662		0.6
Willow/Alder (720)	4,657	366	5,023		4.9
Protection Forest (730)	230	28	258		0.3
Total Forested Non-Productive	18,444	25,932	44,376	--	43.7
Marsh-Muskeg (830)	3,108	4,977	8,085		8.0
Unclassified (840)	69	--	69		--
Total Non-Forested	3,177	4,977	8,154	--	8.0
Grand Total Area	61,465	40,019	101,484	--	100.0
Square Miles	96.0	62.5	158.5		
Percent	60.6	39.4	100.0		

Table V indicates the area by productivity to be lost through flooding in the Rat River Area.

The total area to be lost is 101,484 acres or 158.5 square miles. Churchill Forest Industries (Manitoba) Limited will lose 61,465 acres or 96.0 square miles of which 31,898 acres or 51.9 percent are classed as Forested Productive Land. The Proposed Permanent Forest area will lose 40,019 acres or 62.5 square miles, of which 8,482 acres or 21.2 percent is classed as Forested Productive Land.

Productive Forest Area

The productive forest area to be lost to flooding has been summarized and is presented in Tables VI, VII and VIII. Productive area includes the entire area of land to be lost capable of producing forest ranging from cutting class 0 (potentially productive) to cutting class 5 (overmature). Net Operable Area refers to productive area in cutting classes 4 and 5 having a minimum net merchantable volume of 8 cunits per acre of Jack Pine, Black Spruce, White Spruce and Balsam Fir together, 5 inches and over in diameter at breast height. It is the best of the mature and overmature (cutting classes 4 and 5) portions of the productive area summary. Areas and volumes of cutting class 3 (intermediate) stands having a minimum net merchantable volume of 8 cunits per acre of the four major species have not been included in the Net Operable Summary.

TABLE VI

Summary of Distribution of Area by Working Groups and Cutting Class

-Provincial Crown Land Only-

CFI (61)

Area Removed by Flooding, M.U. 66

(in Acres)

Working Group	Productive Area								Net Operable Area		
	Site	Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	All	1,397	355	3,227	1,541	295	--	6,815	295	--	295
Black Spruce	1	3,111	199	2,825	6,021	1,423	28	13,607	1,286	28	1,314
Black Spruce	2 & 3	3,438	106	822	1,617	374	--	6,357	--	--	--
White Spruce	All	--	--	--	11	--	12	23	--	12	12
Total Softwood	--	7,946	660	6,874	9,190	2,092	40	26,802	1,581	40	1,621
Total Hardwood	All	--	552	4,200	7,104	1,186	--	13,042	--	--	--
Total	--	7,946	1,212	11,074	16,294	3,278	40	39,844	1,581	40	1,621
Percent of Total	--	20.0	3.0	27.8	40.9	8.2	0.1	100.0	97.5	2.5	100.0

TABLE VII

Summary of Distribution of Area by Working Groups and Cutting Classes

-Provincial Crown Land Only-

Proposed Permanent Forest (21)

Area Removed by Flooding, M.U.s 72, 73

(in Acres)

Working Group	Productive Area								Net Operable Area		
	Site	Cutting Class									
		0	1	2	3	4	5	Total	4	5	Total
Jack Pine	All	39	12	798	22	--	--	871	--	--	--
Black Spruce	I	589	287	3,441	1,669	120	--	6,106	120	--	120
Total Softwood	--	628	299	4,239	1,691	120	--	6,977	120	--	120
Total Hardwood	All	--	24	850	1,259	--	--	2,133	--	--	--
Total	--	628	323	5,089	2,950	120	--	9,110	120	--	120
Percent of Total	--	6.9	3.5	55.9	32.4	1.3	--	100.0	100.0	--	100.0

TABLE VIII

Summary of Distribution of Area by Working Groups and Cutting Class

-Provincial Crown Land Only-

Total Area Lost to Flooding

(in Acres)

Working Group	Productive Area								Net Operable Area		
	Site	Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	All	1,436	367	4,025	1,563	295	--	7,686	295	--	295
Black Spruce	1	3,700	486	6,266	7,690	1,543	28	19,713	1,406	28	1,434
Black Spruce	2 & 3	3,438	106	822	1,617	374	--	6,357	--	--	--
White Spruce	All	--	--	--	11	--	12	23	--	12	12
Total Softwood	--	8,574	959	11,113	10,881	2,212	40	33,779	1,701	40	1,741
Total Hardwood	All	--	576	5,050	8,363	1,186	--	15,175	--	--	--
Total	--	8,574	1,535	16,163	19,244	3,398	40	48,954	1,701	40	1,741
Percent of Total	--	17.5	3.1	33.0	39.3	7.0	0.1	100.0	97.7	2.3	100.0

Gross Merchantable Volume

Gross Merchantable Volume estimates of wood to be lost are given in Table IX. The Gross Merchantable Volume is the volume of all species with diameter 3.6 inches at breast height or larger and is calculated on the basis of a 12-inch stump and the following specified top diameters:

a) Jack Pine, Black Spruce and White Spruce - top diameter 3"

b) Balsam Fir, Tamarack Larch and Hardwood species - top diameter 4"

The Gross Merchantable Volume estimate indicates the total wood volume available in Intermediate, Mature and Overmature stands (Cutting Classes 3, 4 and 5) in the project area.

Statistical Reports covering wood volume in the project area as produced by computer analysis are presented with the original report only, under separate cover as Appendix II.

TABLE IX

Gross Merchantable Volume Lost to Flooding in Rat River Watershed

-Provincial Crown Land Only-

(in Cunits)

Species	Proposed Permanent Forest Provincial Crown (21) M.U.s 72, 73			Churchill Forest Industries Provincial Crown (61) M.U. 66			Total Flood Area		
	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	440	180	620	24,930	6,430	31,360	25,370	6,610	31,980
Black Spruce	13,000	1,080	14,080	97,860	6,610	104,470	110,860	7,690	118,550
White Spruce	370	160	530	9,530	7,240	16,770	9,900	7,400	17,300
Balsam Fir	30	20	50	770	110	880	800	130	930
Tamarack Larch	--	--	—	590	--	590	590	—	590
Total Softwood	13,840	1,440	15,280	133,680	20,390	154,070	147,520	21,830	169,350
Trembling Aspen	5,060	880	5,940	77,940	19,970	97,910	83,000	20,850	103,850
Balsam Poplar	530	130	660	6,920	2,880	9,800	7,450	3,010	10,460
White Birch	2,400	10	2,410	8,120	460	8,580	10,520	470	10,990
Total Hardwood	7,990	1,020	9,010	92,980	23,310	116,290	100,970	24,330	125,300
Total	21,830	2,460	24,290	226,660	43,700	270,360	248,490	46,160	294,650

Net Merchantable Volume

Net Merchantable Volume estimates of wood to be lost in the Rat River Project Area are given in Table X. The Net Merchantable Volume is determined by applying cull factors to cover decay, breakage and harvesting loss to be expected in the area. The following cull factors apply in the study area:

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black and White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
All Hardwoods	20%	40%

TABLE X

Net Merchantable Volume Lost to Flooding in Rat River Watershed

-Provincial Crown Land Only-

(in Cunits)

Species	Proposed Permanent Forest Provincial Crown (21) M.U.s 72, 73			Churchill Forest Industries Provincial Crown (61) M.U. 66			Total Flood Area		
	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	400	140	540	22,230	5,460	27,690	22,630	5,600	28,230
Black Spruce	12,180	980	13,160	92,050	5,920	97,970	104,230	6,900	111,130
White Spruce	350	140	490	8,930	6,460	15,390	9,280	6,600	15,880
Balsam Fir	30	20	50	600	80	680	630	100	730
Tamarack Larch	--	--	--	520	--	520	520	--	520
Total Softwood	12,960	1,280	14,240	124,330	17,920	142,250	137,290	19,200	156,490
Trembling Aspen	4,020	530	4,550	61,940	11,940	73,880	65,960	12,470	78,430
Balsam Poplar	430	80	510	5,490	1,700	7,190	5,920	1,780	7,700
White Birch	1,910	10	1,920	6,360	270	6,630	8,270	280	8,550
Total Hardwood	6,360	620	6,980	73,790	13,910	87,700	80,150	14,530	94,680
Total	19,320	1,900	21,220	198,120	31,830	229,950	217,440	33,730	251,170

Net Operable Volume

Net Operable Volume is determined by eliminating all trees in the 4-inch diameter class and all stands which contain less than 800 cubic feet per acre of the four major softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) in cutting classes 4 and 5 only. A summary of the Net Operable Volume to be lost in the Rat River area is given in Table XI. Net Operable Volume represents the volume of the best forest stands in the area.

TABLE XI

Net Operable Volume Lost to Flooding* in Rat River Watershed

-Provincial Crown Land Only-

(in Cunits)

Species	Proposed Permanent Forest (21)				Churchill Forest Industries (61)				Entire Flood Area			
	5" D.b.h.	6"-9" D.b.h.	10"+ D.b.h.	Total	5" D.b.h.	6"-9" D.b.h.	10"+ D.b.h.	Total	5" D.b.h.	6"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	--	--	--	--	520	3,350	870	4,740	520	3,350	870	4,740
Black Spruce	280	540	60	880	3,510	9,570	1,140	14,220	3,790	10,110	1,200	15,100
White Spruce	--	10	--	10	140	870	930	1,940	140	880	930	1,950
Balsam Fir	--	--	--	--	30	60	10	100	30	60	10	100
Total	280	550	60	890	4,200	13,850	2,950	21,000	4,480	14,400	3,010	21,890

*This summary does not include the Net Operable Volume Summary of the Hardwood Working Group.

Effect on Annual Allowable Cut

Annual Allowable Cut calculations have been made for Forest Management Units 66, 72 and 73 in order to provide guidelines for species and volumes available for harvest on an annual basis as required for sustained yield management.

Calculations for the three management units were completed by the Forest Resources Inventory Section, November 8 and 9, 1972. Calculations were made for each working group and in addition for each species. For examination purposes the Practical Annual Allowable Cut was selected, as this calculation gave the volume available for future disposition. A 12% reduction factor has been applied to calculated estimates to cover losses due to fire, new construction and withdrawals from commercial harvesting operations. In examination of the area, therefore, the critical level is a 12% or greater reduction in the annual allowable cut.

1) Forest Management Unit 66

This Management Unit is part of the area committed to Churchill Forest Industries (Manitoba) Limited. Numerically, the greatest volume loss was in the Black Spruce, Site I Working Group, but on recalculation, the Net Operable loss, in terms of area or volume, was found to be under 5 percent. This is within the 12 percent factor built into the original allowable cut calculations. The other working groups were well within the 12 percent allowance as well, the greatest reduction being found in the Net Operable Volume of the White Spruce Working Group where the loss was just over 6 percent.

2) Forest Management Units 72 and 73

These management units are in an area of Proposed Permanent Forest. In the original report, allowable annual cut was calculated for Management Units 71, 72 and 73 together. The losses that will be incurred by flooding to the 850' contour in the Rat River were found to be insignificant. In no working group was the loss found to exceed one percent in volume or area. Numerical loss was greatest to the Black Spruce Site I Working Group.

Timber Clearing

Under present market and transportation conditions, it is not practical to carry out total harvesting of the flood area because production costs would exceed the market value. Some timber can be used in construction for the hydro project. Generally, clearing is not necessary from a forestry viewpoint and must be executed only where it is required for other reasons. This includes channel areas, shore accessibility for travellers in wind-prone spots, future recreation sites and areas near hydro control structures. Merchantable stands in the flood zone should be harvested where economics permit.

Beneficial Effects

The chief benefit to forestry accruing from the project is improved accessibility, primarily by extension of the Ruttan Lake road to the South Bay area and by improvement of existing roads. The roads will provide year-round service and the raised water level will contribute to summer accessibility, providing a route to Southern Indian Lake via the Rat River. Improved accessibility will likely increase tourism as well as provide easier transportation for local people. This may in turn create a greater need for lumber and so improve the economic foundation for portable sawmills.

There should be considerable short-term benefits to the local populace in the form of employment in clearing and construction operations. The training obtained in this manner will be advantageous, both to the people and to the wood-using industry, when future development occurs.

Detrimental Effects

The immediate and most obvious detrimental effect on forestry is the loss of forested land. On the average, Net Operable area is reduced by 3.2 percent with a maximum decrease in Practical Allowable Annual Cut, in the White Spruce Working Group for Management Unit 66, of 6 percent. Only 2.6 percent of land classed as productive area will be inundated. On a sustained yield basis the decrease in allowable cut will eventually balance at that level. Some degradation of productive forest sites is probable through disruption of drainage patterns, but the extent cannot be presently determined.

VII. Conclusions

The Churchill River Diversion Project will cause losses in wood volume and forest area in the Rat River Watershed. These losses are not sufficient to decrease the present annual allowable cut below the 12% margin allowed for unexpected losses. In the long run the allowable cut will be slightly lowered.

A total area of 101,484 acres or 158.5 square miles of land will be lost through the development. Of the total area to be lost, 60.6% falls within the specified area of Churchill Forest Industries (Manitoba) Limited and the remaining 39.4% falls within Proposed Permanent Forest area. Of the total area to be flooded, 48.3% is classified as productive or potentially productive forest land, with the remainder being forested non-productive and non-forested land.

A total of 294,650 cunits of Gross Merchantable Volume will be lost to flooding. This total volume consists of: Jack Pine - 11%, Black Spruce - 40%, White Spruce - 6% for a total Softwood component of 57%; and, Trembling Aspen - 35%, Balsam Poplar - 4%, White Birch - 4% for a total Hardwood component of 43%. Of the Gross Merchantable Volume, 84% is found in the 4"-9" diameter class and 16% in the 10"+ diameter class.

The loss of Net Operable Volume for softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) totals 21,890 cunits which consists of 4,480 cunits (20%) in the 5" diameter class (pulpwood), 14,400 cunits (66%) in the 6"-9" diameter class (small logs and pulpwood) and 3,010 cunits (14%) in the 10"+ diameter class (sawlogs).

Clearing is essential in certain critical sectors of the Project Area. Though harvesting in this remote region is considered at best only marginally economical, it may well reduce the cost of clearing in areas which must be cut in any case. Consideration should be given to harvesting merchantable stands located within the flood zone.

APPENDIX III

Glossary of Terms

Glossary

Brush and Shrub (815) - Areas of private and leased land only, cleared of tree cover for future agricultural use, temporarily covered with brush, shrubs, etc.

Barren-Bare Rock (800) - Tundra and rock with less than 25 percent tree cover.

Cover Type - Four broad cover types are recognized - Softwood "S", Softwood-Hardwood "M", Hardwood-Softwood "N", Hardwood "H". The first number of the type aggregate code indicates the cover type.

Code - 0-3 - Softwood - "S" - includes all stands where at least 76 percent of the total basal area consists of coniferous species.

4-7 - Softwood-Hardwood Mixedwood - "M" - includes all stands where the basal area of all the coniferous species is between 51 percent and 75 percent of the total basal area.

8 - Hardwood-Softwood Mixedwood - "N" - includes all stands where the basal area of all coniferous species is between 26 percent and 50 percent of the total basal area.

9 - Hardwood - "H" - includes all stands where the basal area of all coniferous species is less than 25 percent of the total basal area.

The above cover types are determined by the percent of basal area of softwood in proportion to the total basal area found on all plots taken within a stand.

Crown Closure - This is a stand density estimate made by a photointerpreter. Crown Closure is the percentage of the ground within a stand covered by the crowns of trees located within the stand. The following crown closure classes are recognized in Manitoba:

Forest Regions 1, 2, 4 and 5 and the Whiteshell

Code

0 - applies to potential productive stands only
1 - 15% to 30% crown closure
2 - 31% to 50% crown closure
3 - 51% to 70% crown closure
4 - 71% and over

Forest Regions 3, 6, 7, 8 and 9 excluding the Whiteshell

Code

0 - 0 to 20% crown closure
2 - 21 to 50% crown closure
3 - 51 to 70% crown closure
4 - 71% and over

Cull Factors - Percentage reduction factors by diameter group applied to Gross Merchantable Volume to obtain Net Merchantable Volume. The factors are based on expected and known losses due to decay, damage and shape by species and diameter group. The following factors apply to Forest Regions 3, 5, 6, 7, 8 and 9.

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black Spruce	5%	10%
White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
Hardwoods	20%	40%

Cutting Class - This is a designation applied to forest stands based on size, vigour, state of development and maturity of a stand for harvesting purposes. Five cutting classes are recognized as follows:

Cutting Class 0 - Forest land not restocked following fire, cutting, windfall, or other major disturbances (hence, potentially productive land). Some reproduction or scattered residual trees (with net merchantable volume less than 2.5 cunits per acre may be present).

Cutting Class 1 - Stands which have been restocked either naturally or artificially. There may be scattered residual trees present as in Cutting Class 0. To be in Cutting Class 1, the average height of the stand must be less than 12 feet.

Cutting Class 2 - Advanced young growth of post size, with some merchantable volume. The average height of the stand must be over 12 feet in order to be in this cutting class.

Cutting Class 3 - Immature stands with merchantable volume growing at or near their maximum rate, which definitely should not be cut. The average height of the stand should be over 25 feet and the average diameter should be over 3.6 inches at D.b.h.

Cutting Class 4 - Mature stands which may be cut as they have reached rotation age (± 10 years or ± 20 years on Site 2 black spruce, tamarack larch and eastern cedar).

Cutting Class 5 - Overmature stands which should be given priority in cutting due to susceptability to decay, natural damage and insect attack.

Diameter Breast Height (D.b.h.) - The diameter of a tree measured at breast height (4.5 feet above ground level). Measurement at this point gives a diameter free from butt swell and is a convenient standard point for measurement. Volume estimates are based on diameter at breast height.

Fields (Agriculture) (810) - Areas of private and leased land cleared of tree cover and presently under an agricultural use.

Forest Management Unit - The Forest Management Unit is the basic unit of area considered for Forest Inventory purposes. Forest Management Units have been established on a variety of situations including: status and ownership, administrative units, accessibility, acceptable size and/or forest cover variations.

Forest Regions - There are 9 Forest Regions in the Forest Zone of the Province of Manitoba. Forest Regions have been established based on physical geography and administrative boundaries. Each Forest Region has been further subdivided into Forest Management Units as follows:

1 - Mountain Forest Region - Forest Management Units 11-15

2 - South East Forest Region - Forest Management Units 20-29

3 - Lake Winnipeg East Forest Region - Forest Management Units 30-39

4 - Lowland South Forest Region - Forest Management Units 40-49

5 - Lowland North Forest Region - Forest Management Units 51-57

6 - Northern Mining Forest Region - Forest Management Units 60-66

7 - Northern Transition Forest Region - Forest Management Units 71-75

8 - Nelson River Forest Region - Forest Management Units 81-89

9 - North East Forest Region - Forest Management Units 90-99

0 - Agriculture - Units 01-09

Forest Zone - The Forest Zone is the area which is producing or capable of producing forest crops and which for climatic reasons, is in the main, more suitable for the production of forests than for agricultural crops. The definition of the Forest Zone boundary is essentially the same as the definition of the Wooded District Boundary as presented in "The Fires Prevention Act" of the Province of Manitoba (R.S.M. 1954, Chapter 86).

Gross Merchantable Volume - This is the volume of all species with diameters 3.6" D.b.h. and larger and is found to a specified top diameter and a stump height of one foot. For spruce and pine, top diameter is 3"; for all other species, it is four inches. Volume only in Cutting Classes 3, 4 and 5 is considered.

Increment - annual or periodic increase in volume of a tree or a stand.

Ingrowth - increase of the merchantable volume of a stand as the result of non-merchantable trees (less than 3.5 inches D.b.h.) becoming merchantable during a period of time under consideration.

Marsh-Muskeg (830) - Marsh - Wet lands completely or partially covered with tall grass, rushes or sedges, unsuitable for hay, but can be used as a habitat for fur-bearing animals.

Muskeg - Wet land which has a vegetative cover consisting mainly of sphagnum moss and heath plants with very scattered brush. Black spruce, tamarack or cedar cover does not exceed 25%.

Mud and salt flats around lakes.

Meadow (820) - Moist to wet grassland suitable for hay production (natural hay land).

Mean Annual Increment - The total volume increment up to a given age divided by the age.

Merchantable Volume - The volume of the portion of a tree without bark, excluding the stump (12 inches high) and the top with the bottom diameter of 3 inches inside bark. Merchantable volume of a stand is the sum of the merchantable volume of all trees found in a stand.

Net Merchantable Volume - The Gross Merchantable Volume of all species with diameters 3.6" D.b.h. and larger less the respective cull factors. See Cull Factors.

Net Operable Volume - The Net Merchantable Volume of all operable stands. An operable stand is one which contains a minimum of 800 or greater cubic feet per acre in Cutting Classes 4 and 5 only of the four major Softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) excluding trees 4" D.b.h.

Non-Forested Land - Includes areas a) withdrawn from timber production for a long period of time, such as cultivated fields, hay meadows, pastures, settlements, rights-of-way, gravel pits, beaches, wide ditches, summer resorts, and b) not capable of producing merchantable timber, such as rock, barren, mines, marsh and muskeg.

Non-Productive Forested Land - Includes all forest land not capable of producing merchantable timber due to very low productivity.

Option Area - The area under examination in an Option Licence.

Option Licence - The Minister, with the approval of the Lieutenant-Governor-in-Council and after giving public notice, may issue an option licence to a forest industry for a forest area for a period not exceeding two years in order that the person to whom such a licence is issued may have an opportunity to make examinations and surveys to determine whether or not he wishes to obtain a forest management licence for all or part of such area, and the minister may forbid or restrict the issuance of any other timber licence or permit in the area covered by the Option Licence.

Ownership - The following ownerships of land within the Province of Manitoba are recognized:

Provincial Crown Land - Closed to forest operations	0
Provincial Crown Land - Open to forest operations	1
Provincial Crown - Restricted to forest operations	2
Federal Crown Land	3
Patented (Private) Land	5
Local Government District Land	6
Indian Reserve	7
Other	9

Potential Productive Forest Land - Includes forest land capable of producing merchantable timber, cut temporarily not producing, such as recent burn, clear-cut, or windstorm.

Practical Annual Allowable Cut - This is the amount of timber, by volume or area, based on net operable volume and area that can be cut each year on a sustained yield basis. A 12% reduction is made to all volumes as an allowance for no-cut zones, small scattered stands and fire losses.

Productive Forested Land - Includes all forest land capable of producing merchantable wood within rotation age regardless of its existing stage of productivity.

Productivity - The following diagram indicates the productivity breakdown:

Code

- TOTAL AREA
  - Land (1-899)
    - Forested (1-799)
      - Productive (1-699)
        - Softwood: 'S' (01-39)
        - Softwood-Hardwood Mixedwood: 'M' (40-79)
        - Hardwood-Softwood Mixedwood: 'N' (80-89)
        - Hardwood: 'H' (90-99)
      - Non-Productive (700-799)
        - Treed Muskeg (700)
        - Treed Rock (710)
        - Willow/Alder (720)
        - Protection Forest (730)
    - Non-Forested (800-899)
      - Barren-Bare Rock (800)
      - Fields (Agriculture) (810)
      - Brush & shrub on cleared patent land (815)
      - Meadow (820)
      - Marsh-Muskeg (830)
      - Unclassified (840)
  - Water (900)

Specified Area - All lands (less exceptions) owned by the Province within an area in Northern Manitoba effective April 1, 1966 as defined on Page 3 of the Memorandum of Agreement entered into on February 24, 1966 between the Province of Manitoba and Churchill Forest Industries (Manitoba) Limited. The forests located on the lands so defined were set aside to assure the required wood supply for the forest complex at The Pas, Manitoba.

Status - The term 'status of land' is used to indicate present or proposed committments on the following basis:

Status of Land	Code
Agricultural Zone	0
Provincial Forest	1
Proposed Permanent Forest	2
Licence Berths	4
Pulpwood Berths	5
Specified Areas - Timber Berths	6
Provincial Park	7
INCO Land	8
Agricultural land within the wooded area	9

Subtype - This term indicates the species composition in broad groups within the cover type. Subtype is determined by the proportion of basal area of two or three main species in the stand as found on a sample plot to the total basal area of all species. To determine the subtype, the basal area of indiviual species must be computed and rounded off to the nearest one percent.

Theoretical Annual Allowable Cut - This is the amount of timber, either by volume or area, based on net merchantable volume that can be cut each year on a sustained yield basis.

Treed Muskeg (700) - This is similar to open muskeg, except that the area is supporting semi-stagnated or stagnated trees. Some of the trees may produce "Christmas" trees or fence posts, but will not produce pulpwood size trees or fence posts within a rotation age of 140 years (4"+ D.b.h., height over 30 feet and 2.5 cords of net merchantable volume per acre). At least 26% of the area will be tree-covered.

Treed Rock (710) - Rock with a very shallow soil, supporting semi-stagnated or stagnated trees. At least 26 percent of the area will be tree-covered. These sites do not produce merchantable stands.

Type Aggregate - This term is used in reference to all stands or potentially productive areas in a Management Unit or Forest Section which have common characteristics as to cover type, subtype, site, cutting class, and crown closure.

Unclassified (840) - Rights-of-way, roads, gravel pits, beaches, summer resorts, mines, etc.

Water (900) - Includes lakes and rivers, measured at the high-water mark, able to be delineated on the aerial photographs. Narrow rivers and creeks are not to be considered as separate types, nor as type boundaries.

Willow/Alder (720) - Low-lying areas with a saturated water table presently supporting willow or alder growth. Without improvement these sites are not capable of producing merchantable timber stands.

Working Group - This term is used in reference to all stands or potentially productive areas on the same site and with the same predominant species.

APPENDIX 3 - D

FOREST RESOURCE INVENTORY OF THE AREA BETWEEN THE NOTIGI CONTROL SITE AND THE MANASAN GENERATING SITE ANTICIPATED TO BE FLOODED AS A RESULT OF THE CHURCHILL RIVER DIVERSION PROJECT

FOREST RESOURCE INVENTORY OF THE AREA BETWEEN THE NOTIGI CONTROL SITE AND THE MANASAN GENERATING SITE ANTICIPATED TO BE FLOODED AS A RESULT OF THE CHURCHILL RIVER DIVERSION PROJECT

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July, 1974

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

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SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

ABSTRACT

This report describes the area between the control structure at Notigi and the proposed Wuskwatim and Manasan control structures. A range of contours are examined as well as diversion only without the proposed Wuskwatim or Manasan control structures.

In the Notigi to Wuskwatim section a total of 53,657 acres and Provincial Crown Gross Merchantable Volume of 149,380 cunits will be lost to the 800-foot contour; 80,220 acres and Provincial Crown Gross Merchantable Volume of 272,260 cunits will be lost to the 810-foot contour; and, 39,771 acres and Provincial Crown Gross Merchantable Volume of 139,950 cunits will be lost through diversion only with no structure at Wuskwatim.

In the Wuskwatim to Manasan section a total of 31,933 acres and Gross Merchantable Volume of 84,170 cunits will be lost to the 690-foot contour, 41,875 acres and Gross Merchantable Volume of 109,040 cunits will be lost to the 700-foot contour and 4,030 acres and Gross Merchantable Volume of 7,760 cunits will be lost through diversion only with no structure at Manasan.

A detailed examination of land area and wood volume to be lost is given based on ownership and status of land. The chief detrimental effect is the loss of productive forest area which reduces the allowable annual cut over future years.

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  Net Merchantable
  Net Operable

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Area to be Flooded

VIII. Management Units 65, 66, 87 and 89
810-Foot Contour Notigi - Wuskwatim
Area to be Flooded
Expanded Volume and Summaries
  Gross Merchantable
  Net Merchantable
  Net Operable

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700-Foot Contour Wuskwatim to Manasan
Area to be Flooded

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SUMMARY

I. Recommendations

The Notigi to Manasan section of the Rat and Burntwood Rivers is accessible from the Lynn Lake to Thompson road. This could provide a market for sawn lumber and should facilitate rail transportation of pulpwood. Merchantable stands should be harvested prior to flooding wherever possible. Additional clearing of unmerchantable stands will be necessary in critical areas pertaining to the hydro project.

II. Objectives

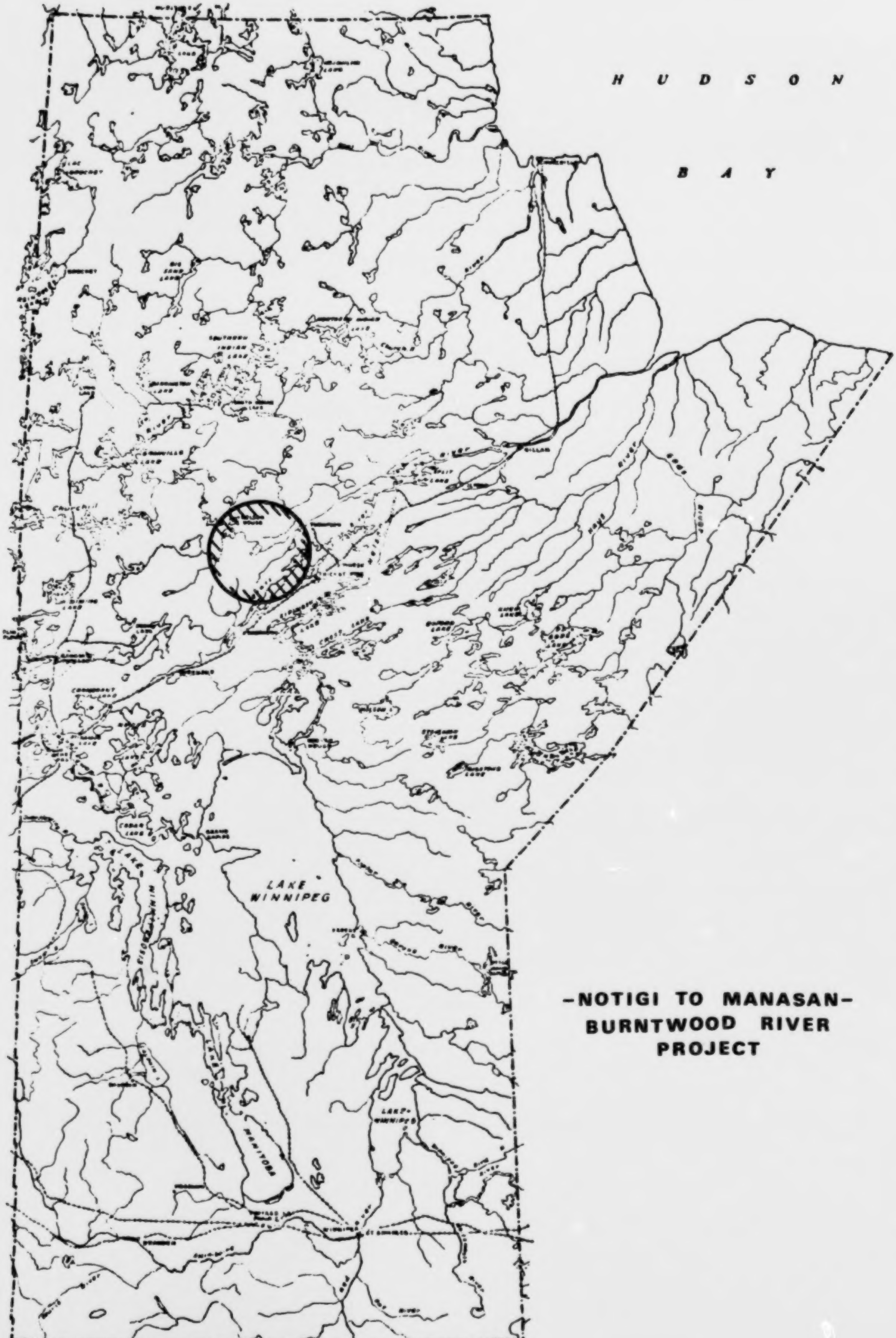
The objectives are to describe the forest cover, to determine area and volume losses, and to assess the implications of these losses in the forest management units involved.

III. Terms of Reference

The study will give the area and volume to be lost through flooding in the Project Area plus an examination of expected beneficial and detrimental effects.

IV. Study Area

The study area covered by this report includes the area from the Notigi control structure downstream to the proposed Wuskwatim control structure, then downstream to the proposed Manasan control structure.


HUDSON
BAY
LAKE WINNIPEG
LAKE WINNIPEGOSIS
LAKE MANITOBA
U.
S.
A.
SURVEYS BRANCH
M&NR - WPG - 1961

-NOTIGI TO MANASAN-
BURNTWOOD RIVER
PROJECT

V. Methodology

Land areas and forest volumes were classified, measured and analyzed on the basis of standard forest inventory procedures used by the Province of Manitoba. The land area to be flooded was determined by superimposing the 800-foot contour line on 4" = 1 mile forest cover maps in Forest Management Units 65, 66 and 87 to the Wuskwatim control structure. Similarly, the 690-foot contour line was superimposed in Forest Management Units 87 and 89 where they will be affected between the Wuskwatim and Manasan structures. The forest cover maps were produced by Forest Inventory and the contour line was superimposed by Surveys Branch personnel.

VI. Observations

The following summary of area and volume losses is provided for ease of comparison between the range of proposals considered in this report.

Proposal	Total Area Loss in Acres				Gross Merchantable Volume Loss (in Cunits)* On Provincial Crown Land Only	Net Merchantable Volume Loss (in Cunits)* On Provincial Crown Land Only	Net Operable Volume Loss (in Cunits)* On Provincial Crown Land Only
	Provincial Crown	Patent	Indian Reserve	Total Area			
I 800-foot Contour** at Wuskwatim	52,501	7	1,149	53,657	149,380	130,720	21,040
II 690-foot Contour at Manasan	31,933	--	--	31,933	84,170	75,050	6,060
III 810-foot Contour at Wuskwatim	78,234	16	1,970	80,220	272,260	238,820	41,830
IV 700-foot Contour	41,875	--	--	41,875	109,040	97,020	8,630
V Diversion Only Notigi to Wuskwatim	37,785	16	1,970	39,771	139,950	121,910	19,410
VI Diversion Only Wuskwatim to Manasan	4,030	--	--	4,030	7,760	6,880	270

*One cunit is equal to 100 cubic feet.

**Proposal I - 800-foot contour at Wuskwatim will be exceeded at all times due to the volume of water moving through the diversion route and a natural control located near Caribou Falls on the Burntwood River.

There are apparently no beneficial effects accruing to forestry in the area due to the hydro project. The main detrimental effect is the loss of productive forest land in Management Unit 65, and to a lesser extent, Unit 66. This is most significant in respect to the White Spruce Working Group in Management Unit 65. In Forest Management Units 87 and 89 there will be a loss of productive forest land resulting in a reduced allowable annual cut. The bulk of this reduction comes in the Black Spruce Site I Working Group of Management Unit 87. Some degradation of additional productive forest sites is probable due to disrupted drainage patterns.

No beneficial effects on forestry are expected as a result of the hydro project in this region. Detrimentally there will be a loss of productive forest land with a corresponding reduction in allowable annual cut.

VII. Conclusions

Flooding above the Manasan control structure to the Wuskwatim structure to the 690-foot contour, thence to the Notigi structure to the 800-foot contour will cause losses in Gross Merchantable Volume of 233,550 cunits and in land area of 85,590 acres. The loss in Net Operable Volume of the four major softwood species consists of 5,050 cunits (19%) in the 5" diameter class, 17,410 cunits (64%) in the 6"-9" diameter class and 4,640 cunits (17%) in the 10"+ diameter class for a total of 27,100 cunits.

Flooding above the Manasan control structure to the Wuskwatim structure to the 700-foot contour, then to the Notigi structure on the 810-foot contour will cause losses in Gross Merchantable Volume of 381,000 cunits and in land area of 122,095 acres. The loss in Net Operable Volume of the four major softwood species consists of 9,460 cunits (19%) in the 5" diameter class, 32,570 cunits (64%) in the 6"-9" diameter class and 8,430 cunits (17%) in the 10"+ diameter class for a total of 50,460 cunits.

Flooding due to diversion only between the Notigi control structure and the Manasan site will cause losses in Gross Merchantable Volume of 147,710 cunits and in land area of 43,801 acres. The loss in Net Operable Volume of the four major softwood species consists of 3,770 cunits (19%) in the 5" diameter class, 12,420 cunits (63%) in the 6"-9" diameter class and 3,490 cunits (18%) in the 10"+ diameter class for a total of 19,680 cunits.

Harvest should be attempted wherever possible in merchantable stands within the flood zone. Clearing may be necessary in specific critical areas irregardless of stand merchantability. It may be possible to salvage some wood from these operations.

REPORT

I. Recommendations

Losses to forestry in the Notigi-Manasan flood area combined with those in the Rat River Area represent a considerable reduction of the allowable annual cut in the White Spruce Working Group. This is unfortunate because of the species in the area, White Spruce is best suited to sawmilling. Harvest of merchantable timber in the flood zone should be made wherever possible. In particular the White Spruce should be cut as boom logs will undoubtably be needed and the other species do not consistently attain sufficient size f[illegible]ose. The remaining White Spruce, the larger Jack Pine and p[illegible]e Black Spruce and Trembling Aspen can be used for construction purposes during work on the project and for continuing local use. Limited amounts of lumber could be used in the immediate area, particularly at Nelson House, but more significantly the area is now accessible to Thompson by road so that lumber from the area could be used in that city.

It seems feasible to locate a sawmill in the area, probably at or near Nelson House, to manufacture this material. It is preferable to locate the sawmill at Nelson House rather than Thompson because it would provide employment for the local people and because it is cheaper to transport lumber than logs to Thompson. Material too small for sawlogs can probably be used by Manitoba Forestry Resources Limited for pulpwood, hauling to railhead at Thompson via the Lynn Lake road or at Wabowden by winter roads and thence by rail to The Pas. In view of the fact that most of the softwood in the area can be used for either sawlogs or pulpwood, any merchantable stands falling in the flood zone should be harvested prior to inundation. Clearing of land occupied by stands unmerchantable either by reason of small tree size, or undesirable species, or low volume per acre may have to be cleared in specific instances for reasons pertaining directly to the hydro project.

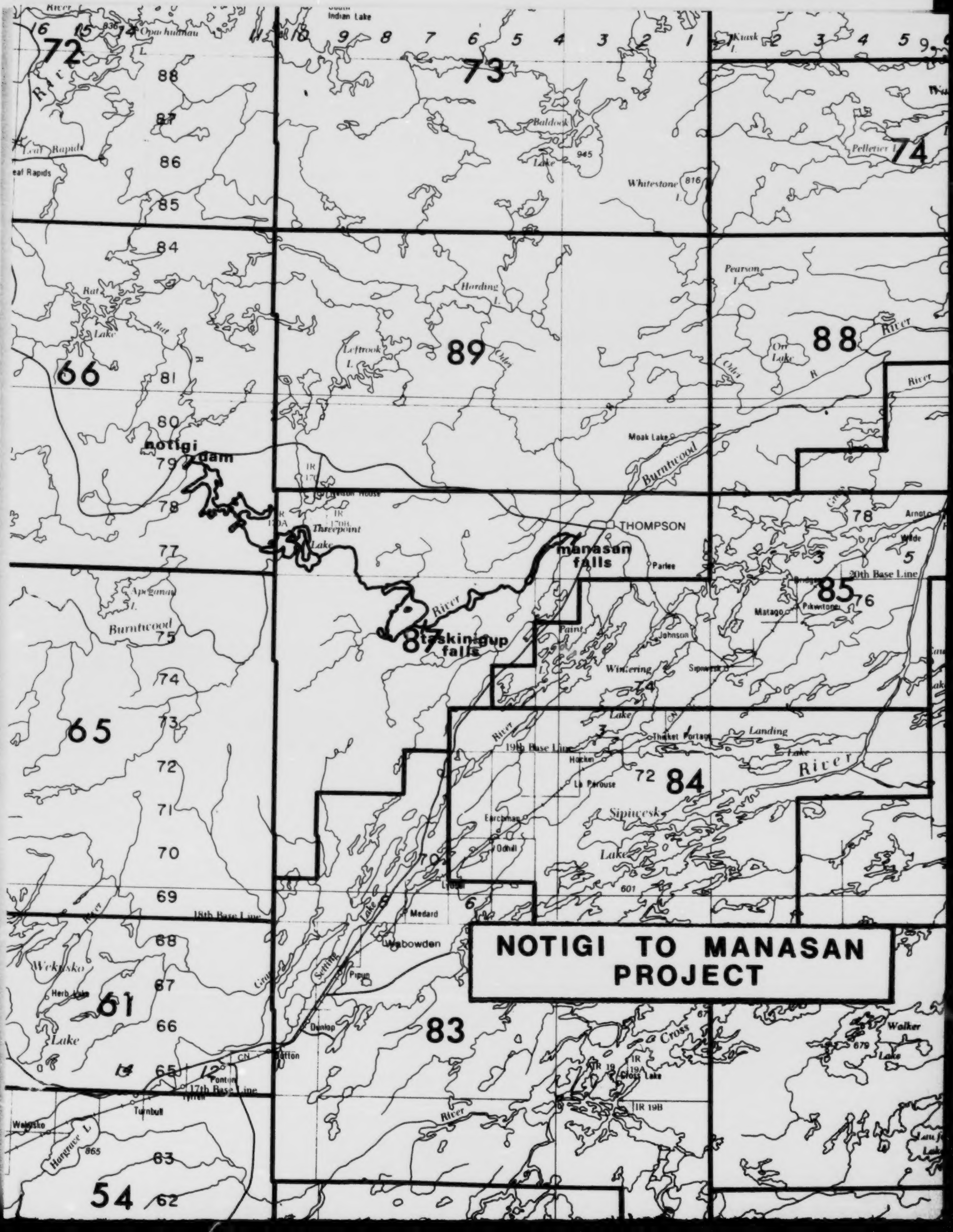
II. Objectives

The object of the study is to determine the area, volume timber type and merchantability of forests which will be affected by inundation in the Notigi to Manasan portion of the Churchill River Diversion Project. The effect of straight diversion with no controls, and the effect of diversion with controls at Wuskwatim (800-foot and 810-foot contours), and Manasan (690-foot and 700-foot contours) will be studied separately.

III. Terms of Reference

For purposes of the study it has been considered that all forest stands below the high-water contour will be affected. Data has been compiled to give the following information separately for straight diversion with no controls and diversion with controls at Wuskwatim (800-foot and 810-foot contours) and Manasan (690-foot and 700-foot contours):

1) Total area to be affected by flooding
2) Area classification regarding forest productivity
3) Merchantable volume, all species
4) Merchantable volume, softwood species
5) Merchantable volume of operable softwood stands
6) Examination of beneficial effects
7) Examination of detrimental effects



NOTIGI TO MANASAN PROJECT

South Indian Lake
Opachuanau L.
Leaf Rapids
Baldock Lake
945
Whitestone L.
816
Kiask
Pelletier L.
Rat Lake
Rat R
Harding L.
Leftrook L.
Odei R
Pearson L.
Ord Lake
Odei R
River
Moak Lake
Burntwood
notigi dam
IR 170
IR 170A
IR 170B
Threepoint Lake
THOMPSON
manasan falls
Partee
Arnot
Wilde
20th Base Line
Matago
Pikwitonei
Apeganau L.
Burntwood
River
taskinigup falls
Paint L.
Johnson
Wintering Lake
Sipiwesk
19th Base Line
Thicket Portage
Landing Lake
River
Hockin
La Pérouse
Earchman
Sipiwesk Lake
Odhill
601
Lyddal
Medard
Wabowden
Setting Lake
Grass
Pipun
Dunlop
Hutton
18th Base Line
Wekusko
Herb Lake
Wekusko Lake
CN
Ponton
17th Base Line
Tyrrell
Turnbull
Wekusko
Hargrave L.
865
Cross Lake
IR 19
IR 19A
IR 19B
Cross Lake
Walker Lake
679
River
72
73
74
66
89
88
65
87
85
84
61
83
54

IV. Study Area

The area to be considered is that section of the Rat and Burntwood Rivers lying between the Notigi Lake control structure on the Rat River and Manasan Falls on the Burntwood River west of Thompson.

The study area falls within Forest Management Units 65, 66, 87 and 89 where the total forest area and volume is committed to Manitoba Forestry Resources Limited, International Nickel Company, Patent (Private) and Indian Reserve.

V. Methodology

A recent, complete Forest Resource Inventory of the project area is available. Aerial photography of the area was flown in 1969 and 1970. The photography is at a scale of four inches to one mile (1:15,840). The field survey was made in the 1971 season by the Forest Resource Inventory Section and compilation of the data was completed in November 1972.

A summary is presented here to outline the inventory system. Complete details of the method of field survey and descriptions of the classification system used are presented in the field cruising manual prepared by the Forest Resource Inventory Section.

Section corners and preliminary typing of the forest stand boundaries were delineated on aerial photographs. Forest types are based on species composition, site, cutting class (maturity) and crown closure (density). Base maps were prepared at a scale of four inches to one mile. These maps were based on ground control established by the Surveys Branch. Detail from the aerial photographs was transferred by sketchmaster to the base maps. The forest cover so delineated was identified by number on a township basis and photointerpreted.

Prism sample plots were established in a variable percentage of the stands identified on the aerial photographs. All species of trees counted in the sample plot were measured for height and diameter at breast height (D.b.h.). In addition the age of one or more trees on each plot was counted to give an age of the stand. Volume per acre estimates were prepared based on the field measurements.

Areas in acres for all stands delineated were determined and the volumes per acre were applied from the appropriate stand/stock volume table giving the expanded wood volumes for the area under consideration.

As a result, all type aggregates of Cutting Class 3 (lowest classification with recognized volume) and higher are based on volumes determined from variable numbers of sample plots which have been measured in the area and which have been located in stands having as similar characteristics as could possibly be determined.

Lands presently not restocked were classified as to site and the most suitable species which the site could support so that possible reforestation programs could be developed for specific areas or the forest management unit as a whole.

Reduced copies of the original forest inventory maps at a scale of one inch to one mile have been prepared for each township in the forest management units as a final step.

Aerial photomosaics were prepared at four inches to one mile and are stored at the Regional Office at The Pas. Copies were made at a scale of two inches to one mile and copies are stored at The Pas and at the Forest Inventory Office in Winnipeg.

The following information has been transferred to forest inventory maps at a scale of four inches to one mile to answer the effect of several flooding proposals:

Proposal I

The 800-foot contour line was transferred for that portion of the project area lying between the Notigi Dam and the proposed Wuskwatim control structure at Taskinigup Falls on the Burntwood River.

Proposal II

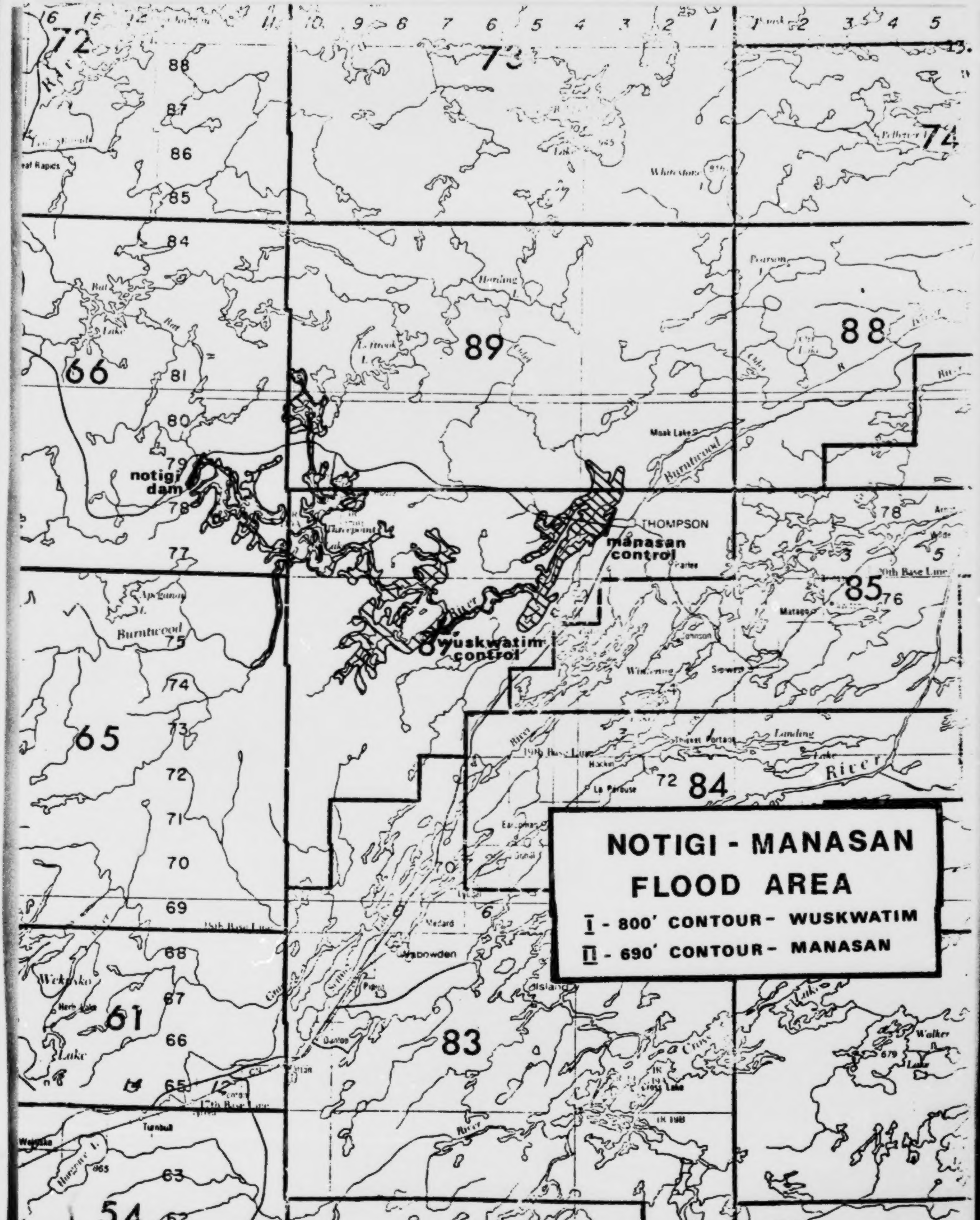
The 690-foot contour line was transferred for that portion of the project area lying between the proposed Wuskwatim control structure at Taskinigup Falls and the proposed Manasan control structure at Manasan Falls on the Burntwood River.

Proposal III

The 810-foot contour line was transferred for that portion of the project area lying between the Notigi Dam and the proposed Wuskwatim control structure at Taskinigup Falls on the Burntwood River.

Proposal IV

The 700-foot contour line was transferred for that portion of the project area lying between the proposed Wuskwatim control structure at Taskinigup Falls and the proposed Manasan control structure at Manasan Falls on the Burntwood River.



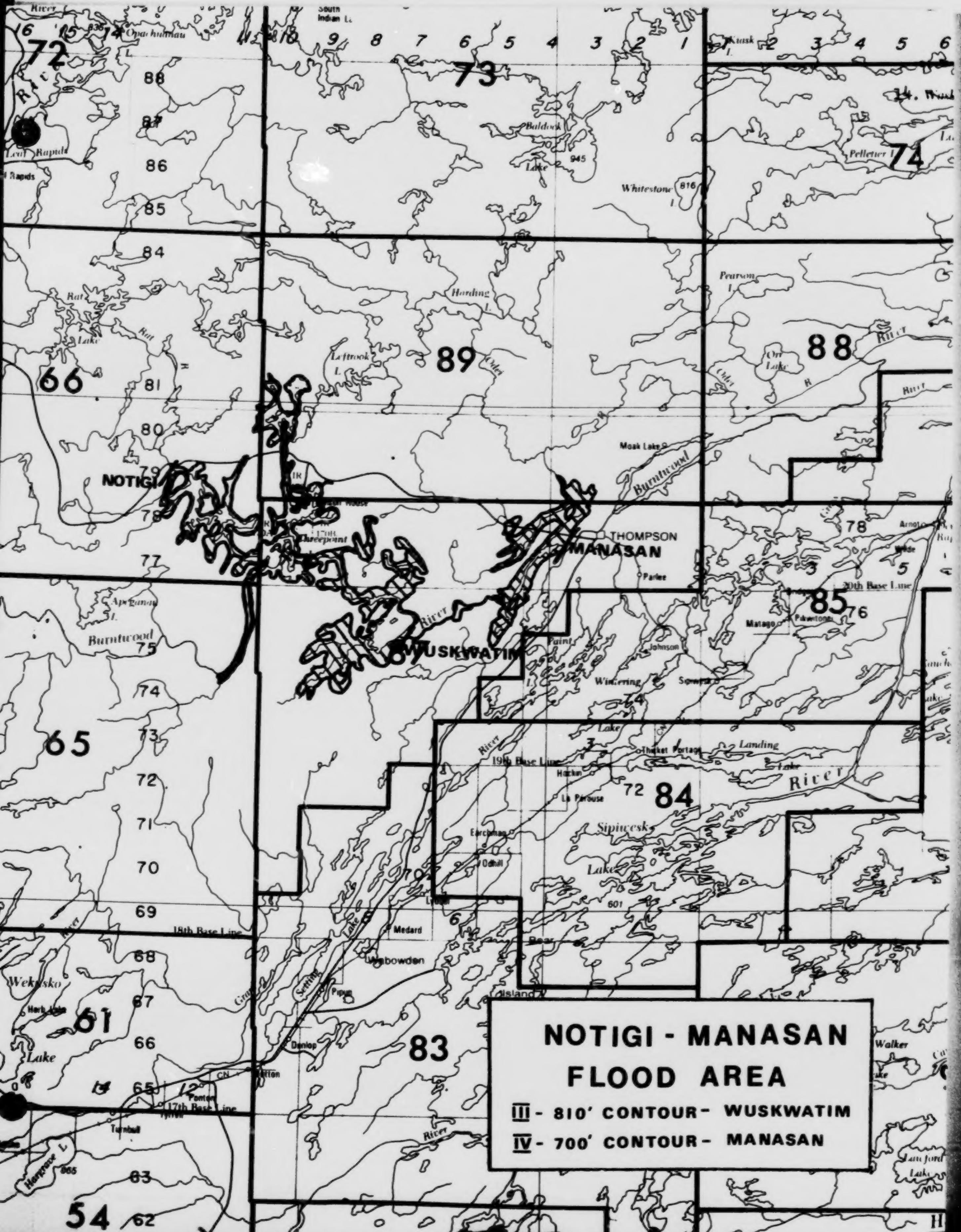
NOTIGI - MANASAN

FLOOD AREA

I - 800' CONTOUR - WUSKWATIM

II - 690' CONTOUR - MANASAN

notigi dam
wuskwatim control
manasan control
THOMPSON
Moak Lake
Burntwood
Wabowden
Thicket Portage
Landing
Lake
River
Pikwitonei
Setting Lake
20th Base Line
19th Base Line
18th Base Line
17th Base Line
72
73
74
66
89
88
65
85
84
61
83
54

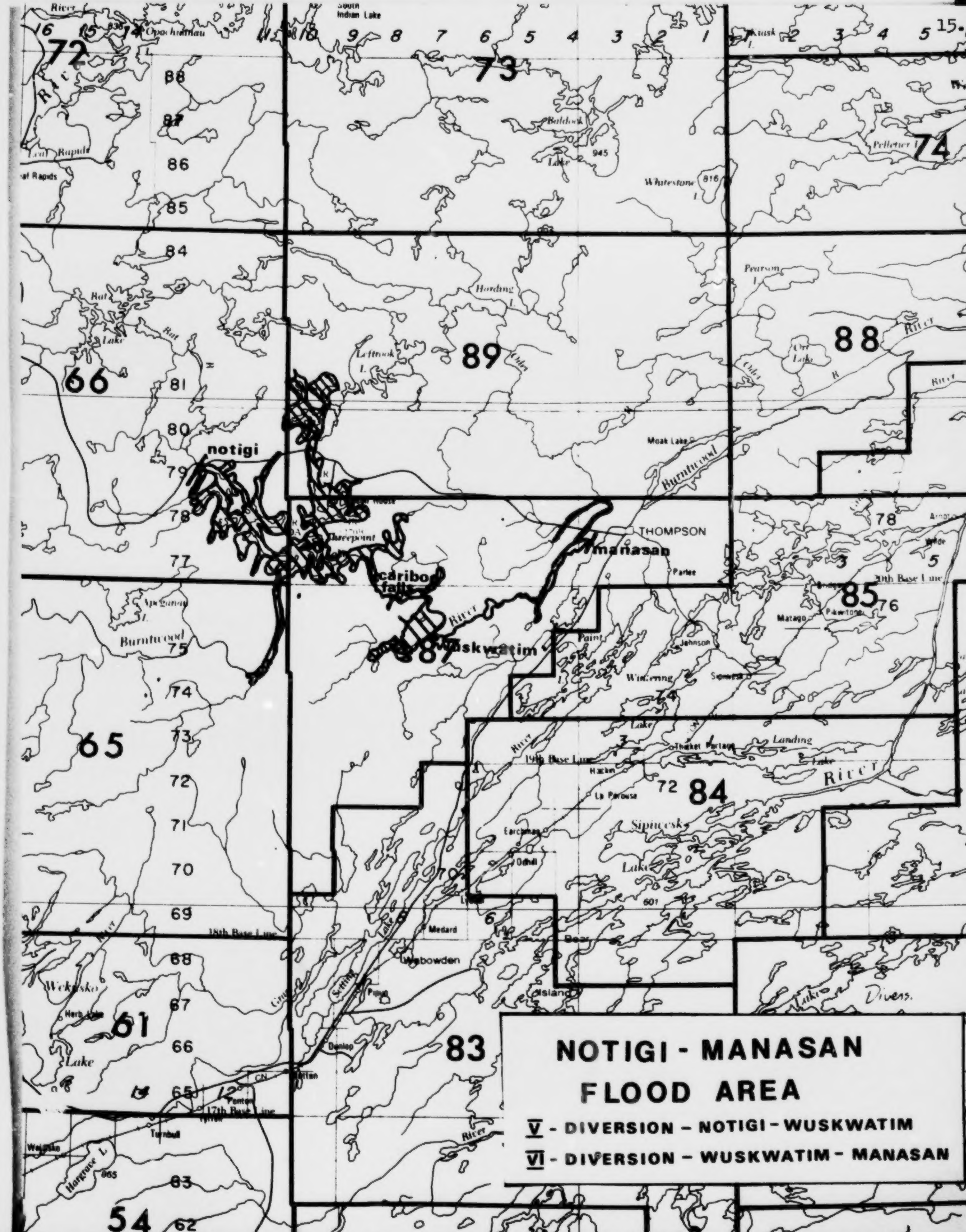


NOTIGI - MANASAN FLOOD AREA

III - 810' CONTOUR - WUSKWATIM

IV - 700' CONTOUR - MANASAN

72
73
74
66
89
88
65
85
84
61
83
54
South Indian L.
Opachuman L.
Leaf Rapids
Baldock Lake
945
Whitestone L.
816
Kusk L.
Pelletier L.
Pearson L.
Harding L.
Leftrook L.
Rat Lake
Rat
Odei
Orr Lake
Odei R
River
Moak Lake
Burntwood
NOTIGI
THOMPSON
MANASAN
Paint
Pelee
Apeganau L.
Burntwood
Threepoint
WUSKWATIM
River
Johnson
Wintering Lake
Sipiwesk
Landing Lake
River
Thicket Portage
19th Base Line
20th Base Line
18th Base Line
17th Base Line
Hockin
La Perouse
Earchman
Odhill
Lake
601
Medard
Wabowden
Bear
Island
Setting Lake
Grass
Pipun
Dunlop
Wekusko Lake
Herb Lake
CN
Ponton
Turnbull
Halfway L.
Matago
Pikwitonei
Arnot
Wilde
Walker
Lanford Lake



NOTIGI - MANASAN FLOOD AREA

V - DIVERSION - NOTIGI - WUSKWATIM

VI - DIVERSION - WUSKWATIM - MANASAN

South Indian Lake
Opachuanau
Leaf Rapids
River
72
73
74
Baldock Lake
945
Whitestone L.
816
Pelletier L
Harding L.
Leftrook L.
Rat Lake
Pearson L.
Orr Lake
Odei R
Burntwood
Moak Lake
89
88
66
65
61
54
83
84
85
87
notigi
Threepoint
cariboo falls
wuskwatim
manasan
THOMPSON
Partee
Apeganau L.
Paint
Johnson
Wintering
Lake
Thicket Portage
Landing
Lake
River
19th Base Line
20th Base Line
18th Base Line
17th Base Line
Hockin
La Perouse
Sipiwesk
Lake
Earchman
Odhill
Medard
Wabowden
Pipun
Setting Lake
Grass
Bear
Island
Dunlop
Mitten
CN
Ponton
Turnbull
Wekusko
Herb Lake
Hargrave L.
865
Matago
Pikwitonei
Arnot
Wilde
Divers.

Proposal V

The area affected by diversion alone was transferred to that portion of the project area lying between the Notigi Dam and the proposed Wuskwatim site.

Proposal VI

The area affected by diversion alone was transferred to that portion of the project area lying between the Wuskwatim site and the Manasan site.

Stand-Stock Volume Tables

For Proposals 1 to 6 the area of land to be lost was calculated and wood volumes involved were determined by applying the productive areas to be lost in acres against the stand-stock volume tables covering the forest management units involved.

A stand-stock volume table was previously developed for Forest Management Units 60 through 66 which fall within the Specified Area of Manitoba Forestry Resources Limited. The volume table is based on trees measured on 12,897 sample plots located throughout the seven management units. A similar stand-stock volume table was previously developed for Management Units 83 - 89 based on trees measured on 11,872 sample plots.

Rotation Period

Rotation periods used for the forest management units within which the project falls were determined on the basis of present market conditions for the various species, the size and type of products for which they were most suited, and the growth rate of these species in the area.

The following rotation ages apply to the various working groups:

Working Group	Years
Jack Pine, All Sites	80
Black Spruce, Site I	80
Black Spruce, Sites II & III	140
White Spruce, All Sites	100
Balsam Fir, All Sites	80
Tamarack Larch, All Sites	140
Hardwoods, All Sites	80

For reference purposes, the following Age Distribution by Cutting Classes are provided for each working group encountered in the Project Area. This gives the approximate age range in years for each cutting class of each working group.

TABLE I

Age Distribution in Years by Cutting Classes and Working Groups

Forest Management Units 65, 66, 87 and 89

Working Group	Cutting Class				
	1	2	3	4	5
Jack Pine, All Sites	1-10	11-25	26-70	71-90	91+
Black Spruce, Site I	1-15	16-30	31-90	91-110	111+
Black Spruce, Sites II & III	1-30	31-75	76-120	121-160	161+
White Spruce, All Sites	1-20	21-30	31-90	91-110	111+
Balsam Fir, All Sites	1-10	11-25	26-70	71-90	91+
Tamarack Larch, All Sites	1-25	26-70	71-120	121-160	161+
Hardwoods, All Sites	1-15	16-30	31-70	71-90	91+

VI. Observations

The tree species found in Management Units 65, 66, 87 and 89 are Black Spruce (*Picea mariana*), White Spruce (*Picea glauca*), Jack Pine (*Pinus banksiana*), Balsam Fir (*Abies balsamea*), Tamarack (*Larix laricina*), Trembling Aspen (*Populus tremuloides*), Balsam Poplar (*Populus balsamifera*) and White Birch (*Betula papyrifera*). Of these species only Black Spruce, White Spruce and Jack Pine are of major commercial importance in the study area at this time. Neither Tamarack nor any of the hardwood species is currently harvested except for local use by residents. Even normally merchantable species have been limited in use by the remoteness of the area. Growth is superior on shorelines and river banks where soils and drainage are generally better than on sites removed from these localities.

VII. Forest Description

Table II is presented to summarize the characteristics of the various forest working groups encountered in the project area.

TABLE II

Characteristics of Working Groups Found in Notigi - Manasan Project Area

Working Group	Site	Tree Cover		Rotation (Years)	D.b.h. Range at Maturity (inches)	Height Range at Maturity (feet)	Gross Merchantable Volume per Acre at Maturity (All Species) Cunits per acre	Landform	Soil Moisture	Drainage
		Primary Species	Associate Species							
Jack Pine	1	**Jack Pine**	Black Spruce Trembling Aspen White Birch	80	6 to 15	55 to 70	17 to 22	Slopes; intermediate terraces and small rock outcrops.	Fresh to moist	Good
Black Spruce	1	**Black Spruce**	White Spruce Trembling Aspen Jack Pine	80	5 to 12	45 to 65	12 to 19	Low glacial till ridges and lacustrine flats.	Moist to wet	Good
Black Spruce	2	**Black Spruce**	Tamarack Larch Balsam Poplar	140	4 to 8	30 to 45	7 to 12	Flat, deep organic terrain.	Wet to saturated	Insufficient
Black Spruce	3	**Black Spruce**	Jack Pine Trembling Aspen Balsam Poplar White Birch	140	4 to 8	30 to 45	7 to 14	Associated with rock outcrops.	Fresh to dry	Excessive
White Spruce	1	**White Spruce**	Trembling Aspen Balsam Fir Black Spruce White Birch	100	10 to 25	55 to 85	30 to 45	Lacustrine flats immediately adjacent to rivers and lakes.	Moist to fresh	Good
Balsam Fir	1	**Balsam Fir**	White Spruce Black Spruce Trembling Aspen Balsam Poplar White Birch	80	6 to 15	45 to 65	15 to 20	Lacustrine flats immediately adjacent to rivers and lakes.	Moist to fresh	Good
Tamarack	1 & 2	**Tamarack**	Black Spruce White Birch	140	4 to 9	30 to 45	0 to 1	Low, spring-fed lacustrine flats; organic flats.	Wet to saturated	Adequate to insufficient
Hardwood	1	**Trembling Aspen** **Balsam Poplar** **White Birch**	White Spruce Black Spruce Balsam Fir Jack Pine	80	8 to 20	55 to 75	15 to 20	Slopes and intermediate terraces, lacustrine flats.	Fresh to very moist	Good

PROPOSAL I

Flooding to the 800-Foot Contour at the Proposed Wuskwatim Control Structure on the Burntwood River

Area to be Lost by Flooding

The land area to be lost through flooding to the 800-foot contour at the proposed Wuskwatim control structure at Taskinigup Falls on the Burntwood River has been calculated to be 53,657 acres or 83.8 square miles. The total land area involved has been summarized and is presented in Tables III & IV. A detailed breakdown of productive forest area only is presented in the following section under Table V.

Statistical reports covering the project area calculations as produced by computer are presented with the original report only, listed under separate cover as Appendices I and II.

Manitoba Forestry Resources Limited will lose 52,501 acres or 82.0 square miles of which 23,550 acres or 44.9% are classed as Forested Productive Land. Private land owners will lose seven acres, none of which is Forested Productive Land. Indian Reserves will lose 1,149 acres or 1.8 square miles of which 557 acres or 48.5% are classed as Forested Productive Land.

Productive Forest Area

The productive forest area to be lost to flooding has been summarized and is presented in Tables V and VI. Productive area includes the entire area of land to be lost capable of producing forest ranging from cutting class 0 (potentially productive) to cutting class 5 (overmature). Net

Operable Area refers to productive area in cutting classes 4 and 5 having a minimum net merchantable volume of eight cunits per acre of Jack Pine, Black Spruce, White Spruce and Balsam Fir together, five inches and over in diameter at breast height. It is the best of the mature and overmature (cutting classes 4 and 5) portions of the productive area summary. Areas and volumes of cutting class 3 (intermediate) stands having a minimum net merchantable volume of eight cunits per acre of the four major species have not been included in the Net Operable Summary.

TABLE III

Area to be Flooded by Ownership and Status of Land

(in Acres)

Township	Manitoba Forestry Resources Ltd. Specified Area Provincial Crown Land (61)	Patent (65)	Indian Reserve (67)	Total Area to be Flooded
74 - 9 W	998			998
11 W	15			15
75 - 7 W	1,050			1,050
8 W	8,927			8,927
9 W	6,056			6,056
11 W	169			169
76 - 7 W	1,513			1,513
8 W	5,725			5,725
9 W	1,986			1,986
11 W	208			208
77 - 7 W	5,381			5,381
8 W	1,168			1,168
9 W	3,045			3,045
10 W	3,356			3,356
11 W	1,724			1,724
12 W	569			569
78 - 7 W	86			86
8 W	136			136
9 W	550	7	178	735
10 W	519		812	1,331
11 W	1,055			1,055
12 W	1,755			1,755
13 W	189			189
79 - 9 W	868		143	1,011
10 W	854		16	870
11 W	720			720
12 W	1,584			1,584
13 W	67			67
80 - 10 W	1,517			1,517
11 W	115			115
81 - 10 W	596			596
Total Area	52,501	7	1,149	53,657
Square Miles	82.0	--	1.8	83.8
Percent	97.9	--	2.1	100.0

TABLE IV

800-Foot Contour Wuskwatim Control Structure

Area to be Lost Through Flooding by Productivity and Status of Land

(in Acres)

Type	Manitoba Forestry Resources Ltd. Provincial Crown (61)	Patent (65)	Indian Reserve (67)	Total Area to be Flooded	% Productivity	% Total Area
Jack Pine, All Sites	4,507		19	4,526	18.8	
Black Spruce, Site I	9,528		313	9,841	40.8	
Black Spruce, Sites II & III	1,598		78	1,676	7.0	
White Spruce, All Sites	213		--	213	0.9	
Tamarack Larch, All Sites	30		--	30	0.1	
Total Softwoods	15,876	--	410	16,286	67.6	--
Hardwoods	4,622	--	91	4,713	19.5	--
Total Forested Productive	20,498	--	501	20,999	87.1	--

TABLE IV (Cont'd)

Type	Manitoba Forestry Resources Ltd. Provincial Crown (61)	Patent (65)	Indian Reserve (67)	Total Area to be Flooded	% Productivity	% Total Area
c.c.o. Jack Pine, All Sites	539		4	543	2.3	
c.c.o. Black Spruce, Site I	1,908		52	1,960	8.1	
c.c.o. Black Spruce, Sites II & III	605		--	605	2.5	
Total Potential Productive	3,052	--	56	3,108	12.9	--
Total Productive	23,550	--	557	24,107	100.0	44.9
Treed Muskeg (700)	17,000		84	17,084		31.9
Treed Rock (710)	9		--	9		--
Willow/Alder (720)	6,692		189	6,881		12.8
Protection Forest (730)	136		--	136		0.3
Total Forested Non-Productive	23,847	--	273	24,120	--	45.0
Marsh-Muskeg (830)	4,712		257	4,969		9.3
Unclassified (840)	392	7	62	461		0.8
Total Non-Forested	5,104	7	319	5,430	--	10.1

TABLE IV (Cont'd)

Type	Manitoba Forestry Resources Ltd. Provincial Crown (61)	Patent (65)	Indian Reserve (67)	Total Area to be Flooded	% Productivity	% Total Area
Grand Total Area	52,501	7	1,149	53,657	--	100.0
Square Miles	82.0	--	1.8	83.8	--	
Percent	97.9	--	2.1	100.0	--	

TABLE V

800-Foot Contour Wuskwatim Control Structure

Summary of Distribution of Productive Area by Working Groups and Cutting Class

-Provincial Crown Land Only-

(in Acres)

Manitoba Forestry Resources Limited

(61)

Area Removed by Flooding, M.U. 65, 66, 87, 89

Working Group	Productive Area								Net Operable Area		
	Site	Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	All	539	1,446	2,262	690	102	7	5,046	102	7	109
Black Spruce	I	1,908	834	2,025	5,234	1,399	36	11,436	1,390	23	1,413
Black Spruce	II & III	605	132	289	1,095	82	--	2,203	--	--	--
White Spruce	All	--	--	--	105	108	--	213	108	--	108
Tamarack Larch	All	--	--	28	2	--	--	30	--	--	--
Total Softwood	--	3,052	2,412	4,604	7,126	1,691	43	18,928	1,600	30	1,630
Total Hardwood	All	--	346	1,347	2,092	822	15	4,622	--	--	--
Total	--	3,052	2,758	5,951	9,218	2,513	58	23,550	1,600	30	1,630
Percent of Total	--	13.0	11.7	25.3	39.1	10.7	0.2	100.0	98.2	1.8	100.0

TABLE VI

800-Foot Contour Wuskwatim Control Structure

Summary of Distribution of Productive Area by Working Group and Cutting Class

(in Acres)

-Provincial Crown Land Only-

Indian Reserve (67)

Area Removed by Flooding, M.U. 87, 89

Working Group	Site	Productive Area							Net Operable Area		
		Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	I	4	--	--	12	7	--	23	7	--	7
Black Spruce	I	52	--	9	211	93	--	365	93	--	93
Black Spruce	II	--	9	2	40	27	--	78	--	--	--
Total Softwood	--	56	9	11	263	127	--	466	100	--	100
Total Hardwood	All	--	--	21	30	32	8	91	--	--	--
Total	--	56	9	32	293	159	8	557	100	--	100
Percent of Total	--	10.1	1.6	5.8	52.6	28.5	1.4	100.0	100.0	--	100.0

Gross Merchantable Volume

Gross Merchantable Volume estimates of wood to be lost are given in Table VII. The Gross Merchantable Volume is the volume of all species with diameter 3.6 inches at breast height or larger and is calculated on the basis of a 12-inch stump and the following specified top diameters:

a) Jack Pine, Black Spruce and White Spruce - top diameter 3"

b) Balsam Fir, Tamarack Larch and Hardwood species - top diameter 4"

The Gross Merchantable Volume estimate indicates the total wood volume available in Intermediate, Mature and Overmature stands (cutting classes 3, 4 and 5) in the project area.

Statistical reports covering wood volume in the project area as produced by computer analysis are presented with the original report only, under separate cover as Appendices IV and V.

TABLE VII

800-Foot Contour Wuskwatim Control Structure

Gross Merchantable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Limited Provincial Crown (61) M.U. 87, 89, 65, 66		
	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	12,170	2,910	15,080
Black Spruce	70,550	4,800	75,350
White Spruce	6,140	6,270	12,410
Balsam Fir	870	150	1,020
Tamarack Larch	220	--	220
Total Softwood	89,950	14,130	104,080
Trembling Aspen	30,910	6,280	37,190
Balsam Poplar	2,660	750	3,410
White Birch	4,420	280	4,700
Total Hardwood	37,990	7,310	45,300
Total	127,940	21,440	149,380

Net Merchantable Volume

Net Merchantable Volume estimates of wood to be lost in the Notigi Dam to the proposed Wuskwatim Control Structure are given in Table VIII. The Net Merchantable Volume is determined by applying cull factors to cover decay, breakage and harvesting loss to be expected in the area. The following cull factors apply in the study area:

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black and White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
All Hardwoods	20%	40%

TABLE VIII

800-Foot Contour Wuskwatim Control Structure

Net Merchantable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Limited Provincial Crown (61) M.U. 87, 89, 65, 66		
	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	10,850	2,450	13,300
Black Spruce	66,330	4,260	70,590
White Spruce	5,770	5,590	11,360
Balsam Fir	740	90	830
Tamarack Larch	190	--	190
Total Softwood	83,880	12,390	96,270
Trembling Aspen	24,570	3,680	28,250
Balsam Poplar	2,110	390	2,500
White Birch	3,540	160	3,700
Total Hardwood	30,220	4,230	34,450
Total	114,100	16,620	130,720

Net Operable Volume

Net Operable Volume is determined by eliminating all trees in the 4-inch diameter class and all stands which contain less than 800 cubic feet per acre of the four major softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) in cutting classes 4 and 5 only. A summary of the Net Operable Volume to be lost in the Notigi Dam to the proposed Wuskwatim Control Structure is given in Table IX. Net Operable Volume represents the volume of the best forest stands in the area.

TABLE IX
800-Foot Contour Wuskwatim Control Structure
(in Cunits)
Net Operable Volume Lost to Flooding*
-Provincial Crown Land Only-

Species	Manitoba Forestry Resources (61)			
	5" D.b.h.	6"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	270	1,670	430	2,370
Black Spruce	3,570	10,150	1,360	15,080
White Spruce	190	1,320	1,790	3,300
Balsam Fir	60	190	40	290
Total	4,090	13,330	3,620	21,040

*This summary does not include the Net Operable Volume Summary of the Hardwood Working Group.

Effect on Annual Allowable Cut

Portions of Forest Management Units 65, 66, 87 and 89 will be affected by the 800-foot contour above the proposed Wuskwatim control structure. Calculations for each of the four forest management units have been completed by the Forest Resource Inventory Section on the basis of working group and species to provide wood volumes available for harvest on a sustained yield basis. To determine the effects of flooding, the Practical Annual Cut was examined as this represents the wood volume available for use at the present time. In the original calculations a 12% reduction factor has been applied to calculated estimates to cover losses due to fire, new construction and other withdrawals from commercial harvesting operations. In examination of the area, therefore, the critical level is a 12% or greater reduction in the practical annual allowable cut.

1) Forest Management Unit 65

Productive area losses and resulting volume losses are not significant enough to affect the allowable cut.

2) Forest Management Unit 66

Numerically, the greatest volume loss was in the Black Spruce, Site I, Working Group, but on recalculation the resulting reduction in the Black Spruce annual cut was less than 1%. When combined with additional losses lying along the Rat River above the Notigi Dam, the reduction in the Black Spruce annual cut rises to 5% which is still well within the 12% limit.

The greatest reduction on a percentage basis occurs in the White Spruce Working Group. The reduction required due to the proposed 800-foot contour at Wuskwatim would be 9%. When combined with additional losses above the Notigi Dam the reduction required rises to 11%. Any additional flooding would require a recalculation of the White Spruce annual allowable cut in this forest management unit.

The effect on the allowable cut for all other species is negligible.

3) Forest Management Unit 87

This management unit absorbes most of the loss caused by the flooding to the 800-foot contour at the proposed Wuskwatim control structure. Three "Status of Land" and Ownerships are involved: Manitoba Forestry Resources Limited, Private, and Indian Reserve.

The greatest loss occurs in the Black Spruce Site I Working Group where a reduction of 11% would be encountered. This is just within the guiding 12% factor.

The effect on the allowable cut for all other species is negligible.

4) Forest Management Unit 89

Productive area losses and resulting volume losses are not significant enough to affect the allowable cut.

PROPOSAL II

Flooding to the 690-Foot Contour at the Proposed Manasan Control Structure on the Burntwood River

Area to be Lost by Flooding

Table XI indicates the area by productivity to be lost through flooding to the 690-foot contour at the Manasan Control Structure.

The total land area to be lost is 31,933 acres or 49.9 square miles. Manitoba Forestry Resources Limited will lose 31,245 acres or 48.8 square miles of which 23,955 acres or 76.7 percent are classed as Forested Productive Land. The INCO area will lose 688 acres or 1.1 square miles of which 513 acres or 74.6 percent are classed as Forested Productive Land. A detailed breakdown of productive forest area only is presented in the following section under Tables XII and XIII.

Statistical reports covering the project area calculations as produced by computer are presented with the original report only, under separate cover as Appendix V.

Productive Forest Area

The productive forest area to be lost to flooding has been summarized and is presented in Tables XII and XIII. Productive area includes the entire area of land to be lost capable of producing forest ranging from cutting class 0 (potentially productive) to cutting class 5 (overmature). Net Operable Area refers to productive area in cutting classes 4 and 5 having a minimum net merchantable volume of 8 cunits per acre of Jack Pine, Black Spruce, White Spruce and Balsam Fir together, 5 inches and over in diameter at breast height. It is the best of the mature and overmature (cutting classes 4 and 5) portions of the productive area summary. Areas and volumes of cutting class 3 (intermediate) stands having a minimum net merchantable volume of 8 cunits per acre of the four major species have not been included in the Net Operable Summary.

TABLE X

690-Foot Contour at the Proposed Manasan Control Structure

Area to be Flooded by Ownership and Status of Land

(in Acres)

Township	Manitoba Forestry Resources Ltd. Specified Area Provincial Crown (61)	INCO Provincial Crown (81)	Total Area to be Flooded
75 - 5 W	940	60	1,000
7 W	91		91
76 - 4 W	1		1
5 W	7,502	628	8,130
6 W	325		325
7 W	42		42
77 - 4 W	4,513		4,513
5 W	2,062		2,062
78 - 3 W	1,644		1,644
4 W	12,683		12,683
5 W	1,726		1,726
79 - 3 W	1,039		1,039
4 W	444		444
Total Area	33,012	688	33,700*
Square Miles	51.6	1.1	52.7
Percent	98.0	2.0	100.0

*Includes 1,767 acres of water.

TABLE XI

690-Foot Contour at the Proposed Manasan Control Structure

Land Area to be Lost Through Flooding by Productivity and Status of Land*

(in Acres)

Type	Manitoba Forestry Resources Limited	INCO	Total Area to be Flooded	% Productivity	% Total Area
	Provincial Crown (61)	Provincial Crown (81)			
Jack Pine, All Sites	3,903	212	4,115	16.8	
Black Spruce, Site I	8,225	150	8,375	34.2	
Black Spruce, Sites II & III	2,310	49	2,359	9.7	
Total Softwoods	14,438	411	14,849	60.7	--
Hardwoods	1,062	13	1,075	4.4	--
Total Forested Productive	15,500	424	15,924	65.1	--
c.c.o. Jack Pine, All Sites	4,355	--	4,355	17.8	
c.c.o. Black Spruce, Site I	3,446	89	3,535	14.4	
c.c.o. Black Spruce, Sites II & III	654	--	654	2.7	
Total Potential Productive	8,455	89	8,544	34.9	--
Total Productive	23,955	513	24,468	100.0	76.6

TABLE XI (Cont'd)

Type	Manitoba Forestry Resources Limited	INCO	Total Area to be Flooded	% Productivity	% Total Area
	Provincial Crown (61)	Provincial Crown (81)			
Treed Muskeg (700)	3,435	107	3,542		
Treed Rock (710)	1	--	1		
Willow/Alder (720)	1,351	--	1,351		
Protection Forest (730)	1	--	1		
Total Forested Non-Productive	4,788	107	4,895	--	15.3
Marsh-Muskeg (830)	2,381	68	2,449		
Unclassified (840)	121	--	121		
Total Non-Forested	2,502	68	2,570	--	8.1
Grand Total Area	31,245	688	31,933	--	100.0
Square Miles	48.8	1.1	49.9		
Percent	97.8	2.2	100.0		

*Does not include the 1,767 acres of water in Table X.

TABLE XII

690-Foot Contour at the Proposed Manasan Control Structure

Summary of Distribution of Productive Area by Working Group and Cutting Class

Manitoba Forest Resources Limited-61

-Provincial Crown Land Only-

Area Removed by Flooding, F.M.U. 87, 89

Working Group	Productive Area								Net Operable Area		
	Site	Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	All	4,355	1,576	641	1,435	251	--	8,258	159	--	159
Black Spruce	I	3,446	1,539	1,941	4,217	522	6	11,671	412	6	418
Black Spruce	II & III	654	881	570	791	68	--	2,964	--	--	--
Total Softwood	--	8,455	3,994	3,152	6,443	841	6	22,893	571	6	577
Total Hardwood	All	--	160	223	526	153	--	1,062	--	--	--
Total	--	8,455	4,156	3,375	6,969	994	6	23,955	571	6	577
Percent of Total	--	35.3	17.4	14.1	29.1	4.1	--	100.0	99.0	1.0	100.0

TABLE XIII

690-Foot Contour at the Proposed Manasan Control Structure

Summary of Distribution of Productive Area by Working Groups and Cutting Class

(in Acres)

-Provincial Crown Land Only-

(INCO - 81)

Area Removed by Flooding, F.M.U. 87, 89

Working Group	Productive Area							
	Site	Cutting Class						
		0	1	2	3	4	5	Total
Jack Pine	I	--	--	108	104	--	--	212
Black Spruce	I	89	11	72	67	--	--	239
Black Spruce	II	--	23	--	26	--	--	49
Total Softwood	--	89	34	180	197	--	--	500
Total Hardwood	All	--	5	--	8	--	--	13
Total	--	89	39	180	205	--	--	513
Percent of Total	--	17.3	7.6	35.1	40.0	--	--	100.0

Gross Merchantable Volume

Gross Merchantable Volume estimates of wood to be lost are given in Table XIV. The Gross Merchantable Volume is the volume of all species with diameter 3.6 inches at breast height or larger and is calculated on the basis of a 12-inch stump and the following specified top diameters:

a) Jack Pine, Black Spruce and White Spruce - top diameter 3"

b) Balsam Fir, Tamarack Larch and Hardwood species - top diameter 4"

The Gross Merchantable Volume estimate indicates the total wood volume available in Intermediate, Mature and Overmature stands (cutting classes 3, 4 and 5) in the project area.

Statistical reports covering wood volume in the project area as produced by computer analysis are presented with the original report only, under separate cover as Appendix VI.

TABLE XIV

690-Foot Contour at the Proposed Manasan Control Structure

Gross Merchantable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Ltd. Provincial Crown (61) M.U. 87, 89			INCO Provincial Crown (81) M.U. 87, 89			Total Flood Area		
	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	14,150	2,510	16,660	700	60	760	14,850	2,570	17,420
Black Spruce	43,030	2,670	45,700	880	50	930	43,910	2,720	46,630
White Spruce	1,540	1,580	3,120	20	20	40	1,560	1,600	3,160
Balsam Fir	160	10	170	--	--	--	160	10	170
Tamarack Larch	190	--	190	--	--	--	190	--	190
Total Softwood	59,070	6,770	65,840	1,600	130	1,730	60,670	6,900	67,570
Trembling Aspen	11,030	1,650	12,680	360	40	400	11,390	1,690	13,080
Balsam Poplar	1,290	220	1,510	30	--	30	1,320	220	1,540
White Birch	1,850	90	1,940	40	--	40	1,890	90	1,980
Total Hardwood	14,170	1,960	16,130	430	40	470	14,600	2,000	16,600
Total	73,240	8,730	81,970	2,030	170	2,200	75,270	8,900	84,170

Net Merchantable Volume

Net Merchantable Volume estimates of wood to be lost in the Wuskwatim to Manasan Project Area are given in Table XV. The Net Merchantable Volume is determined by applying cull factors to cover decay, breakage and harvesting loss to be expected in the area. The following cull factors apply in the study area:

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black and White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
All Hardwoods	20%	40%

TABLE XV

690-Foot Contour at the Proposed Manasan Control Structure

Net Merchantable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Ltd. Provincial Crown (61) M.U. 87, 89			INCO Provincial Crown (81) M.U. 87, 89			Total Flood Area		
	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	12,710	2,080	14,790	620	50	670	13,330	2,130	15,460
Black Spruce	40,410	2,390	42,800	810	50	860	41,220	2,440	43,660
White Spruce	1,470	1,430	2,900	20	20	40	1,490	1,450	2,940
Balsam Fir	130	10	140	--	--	--	130	10	140
Tamarack Larch	170	--	170	--	--	--	170	--	170
Total Softwood	54,890	5,910	60,800	1,450	120	1,570	56,340	6,030	62,370
Trembling Aspen	8,710	1,000	9,710	290	20	310	9,000	1,020	10,020
Balsam Poplar	1,010	100	1,110	20	--	20	1,030	100	1,130
White Birch	1,470	40	1,510	20	--	20	1,490	40	1,530
Total Hardwood	11,190	1,140	12,330	330	20	350	11,520	1,160	12,680
Total	66,080	7,050	73,130	1,780	140	1,920	67,860	7,190	75,050

Net Operable Volume

Net Operable Volume is determined by eliminating all trees in the 4-inch diameter class and all stands which contain less than eight cunits per acre of the four major softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) in cutting classes 4 and 5 only. A summary of the Net Operable Volume to be lost in the Wuskwatim to Manasan area is given in Table XVI. Net Operable Volume represents the volume of the best forest stands in the area.

TABLE XVI
690-Foot Contour at the Proposed Manasan Control Structure
Net Operable Volume Lost to Flooding*
(in Cunits)
-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Limited-61			
	5" D.b.h.	6"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	140	1,200	370	1,710
Black Spruce	810	2,680	390	3,880
White Spruce	10	180	260	450
Balsam Fir	--	20	--	20
Total	960	4,080	1,020	6,060

*This summary does not include the Net Operable Volume Summary of the Hardwood Working Group.

Effect on Annual Allowable Cut

Portions of forest management units 87 and 89 are affected by flooding in this proposal. Calculations for each of the management units were made by the Forest Resources Inventory Section on the basis of Working Group and Species to provide wood volumes available for harvest on a sustained yield basis. To determine the effects of flooding, the Practical Annual Allowable Cut was examined as this calculation gave the volume available for future disposition. In the original calculations a 12% reduction factor has been applied to calculated estimates to cover losses due to fire, new construction and withdrawals from commercial harvesting operations. In examination of the area, therefore, the critical level is a 12% or greater reduction in the annual allowable cut. Management Unit 87 was most affected.

1) Forest Management Unit 87

This management unit has two status of Provincial Crown Lands affected within it: Manitoba Forestry Resources Limited and International Nickel Company Limited. Volume loss to Black Spruce was 3,880 cunits which was more than any other species. Recalculation shows that this portion of the flooding will reduce the allowable annual cut in the Black Spruce Site I Working Group of Management Unit 87 by 2.8 percent. This in itself is not significant being well within the 12% factor built into the original allowable cut calculations but the flooding above the Wuskwatim control structure within Forest Management Unit 87 will result in a further 10.8 percent reduction in the same working group. The total loss is then in excess of the 12% loss factor so a recalculation of the allowable cut will be required and a reduction in available volume will result.

2) Forest Management Unit 89

Forest Management Unit 89 will be affected only by the extreme northern part of the flooding from the Wuskwatim and Manasan structures. This will result in a small volume and productive area loss, but will not require a change in the allowable cut.

PROPOSAL III

Flooding to the 810-Foot Contour at the Proposed Wuskwatim Control Structure on the Burntwood River

Area to be Lost by Flooding

The land area to be lost through flooding to the 810-foot contour at the proposed Wuskwatim control structure at Taskinigup Falls on the Burntwood River has been calculated to be 80,220 acres or 125.3 square miles. The total land area involved has been summarized and is presented in Tables XVII and XVIII. A detailed breakdown of productive forest area only is presented in the following section under Table XVIII.

Statistical reports covering the project area calculations as produced by computer are presented with the original report only, listed under separate cover as Appendices VII and VIII.

Manitoba Forestry Resources Limited will lose 62,109 acres or 122.2 square miles of which 40,868 acres or 52.2% are classed as Forested Productive Land. Private land owners will lose 16 acres, none of which is Forested Productive Land. Indian Reserves will lose 1,970 acres or 3.1 square miles of which 1,293 acres or 65.6% are classified as Forested Productive Land.

Productive Forest Area

The productive forest area to be lost to flooding has been summarized and is presented in Tables XIX and XX. Productive area includes the entire area of land to be lost capable of producing forest ranging from cutting class 0 (potentially productive) to cutting class 5 (overmature). Net Operable Area refers to productive area in cutting classes 4 and 5 having

TABLE XVII

Area to be Flooded by Ownership and Status of Land

(in Acres)

Township	Manitoba Forestry Resources Ltd. Specified Area Provincial Crown Land (61)	Patent (65)	Indian Reserve (67)	Total Area to be Flooded
74 - 9W	2,236			2,236
11W	44			44
75 - 7W	1,622			1,622
8W	10,051			10,051
9W	8,418			8,418
11W	363			363
76 - 7W	2,224			2,224
8W	8,198			8,198
9W	3,829			3,829
11W	395			395
77 - 7W	7,361			7,361
8W	2,281			2,281
9W	5,305			5,305
10W	4,330			4,330
11W	2,478			2,478
12W	771			771
78 - 7W	312			312
8W	798			798
9W	1,093	16	303	1,412
10W	804		1,417	2,221
11W	1,732			1,732
12W	2,966			2,966
13W	318			318
79 - 9W	1,455		219	1,674
10W	1,421		31	1,452
11W	1,244			1,244
12W	1,548			1,548
13W	67			67
80 - 10W	2,370			2,370
11W	635			635
81 - 10W	1,565			1,565
Total Area	78,234	16	1,970	80,220
Square Miles	122.2	--	3.1	125.3
Percent	97.5	--	2.5	100.0

TABLE XVIII

810-Foot Contour Wuskwatim Control Structure

Area to be Lost Through Flooding by Productivity and Status of Land

(in Acres)

Type	Manitoba Forestry Resources Ltd. Provincial Crown (61)	Patent (65)	Indian Reserve (67)	Total Area to be Flooded	% Productivity	% Total Area
Jack Pine, All Sites	7,933		44	7,977	18.9	
Black Spruce, Site I	16,298		718	17,016	40.4	
Black Spruce, Sites II & III	2,733		183	2,916	6.9	
White Spruce, All Sites	307		--	307	0.7	
Tamarack Larch, All Sites	59		--	59	0.1	
Total Softwoods	27,330	--	945	28,275	67.0	--
Hardwoods	7,583	--	173	7,756	18.4	--
Total Forested Productive	34,913	--	1,118	36,031	85.4	--
c.c.o. Jack Pine, All Sites	1,094		6	1,100	2.6	
c.c.o. Black Spruce, Site I	3,534		169	3,703	8.8	
c.c.o. Black Spruce Sites II & III	1,327		--	1,327	3.2	
Total Potential Productive	5,955	--	175	6,130	14.6	
Total Productive	40,868	--	1,293	42,168	100.0	52.6
Treed Muskeg (700)	24,505		184	24,689		30.8
Treed Rock (710)	47		--	47		0.1
Willow/Alder (720)	7,067		184	7,251		9.0
Protection Forest (730)	177		--	177		0.2
Total Forested Non-Productive	31,796	--	368	32,164	--	40.1

TABLE XVIII (Cont'd)

Type	Manitoba Forestry Resources Ltd. Provincial Crown (61)	Patent (65)	Indian Reserve (67)	Total Area to be Flooded	% Productivity	% Total Area
Marsh-Muskeg (830)	5,241		239	5,480		6.8
Unclassified (840)	329	16	70	415		0.5
Total Non-Forested	5,570	16	309	5,895		7.3
Grand Total Area	78,234	16	1,970	80,186	--	100.0
Square Miles	122.2	--	3.1	125.3	--	--
Percent	97.6	--	2.4	100.0	--	--

TABLE XIX

810-Foot Contour Wuskwatim Control Structure

Summary of Distribution of Productive Area by Working Groups and Cutting Class

-Provincial Crown Land Only-

(in Acres)

Manitoba Forestry Resources Limited

Area Removed by Flooding, M.U. 65, 66, 87, and 89

Working Group	Productive Area									Net Operable Area		
	Site	Cutting Class								4	5	Total
		0	1	2	3	4	5	Total				
Jack Pine	All	1,094	2,632	3,634	1,310	347	10	9,027		347	10	357
Black Spruce	I	3,534	1,546	3,332	8,859	2,499	62	19,832		2,408	49	2,457
Black Spruce	II & III	1,327	284	511	1,790	148	--	4,060		--	--	--
White Spruce	All	--	--	--	155	152	--	307		142	--	142
Tamarack Larch	All	--	--	31	28	--	--	59		--	--	--
Total Softwood	--	5,955	4,462	7,508	12,142	3,146	72	33,285		2,897	59	2,956
Total Hardwood	All	--	730	2,010	3,352	1,459	32	7,583		--	10	10
Total		5,955	5,192	9,518	15,494	4,605	104	40,868		2,897	69	2,966
Percent of Total		14.6	12.7	23.3	37.9	11.3	0.2	100.0		97.7	2.3	100.0

TABLE XX

810-Foot Contour Wuskwatim Control Structure

Summary of Distribution of Productive Area by Working Group and Cutting Class

(in Acres)

-Provincial Crown Land Only-

Indian Reserve (67)

Area Removed by Flooding, M.U. 87, 89

Working Group	Productive Area								Net Operable Area		
	Site	Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	I	6	--	--	21	23	--	50	23	--	23
Black Spruce	I	169	--	44	438	236	--	887	236	--	236
Black Spruce	II	--	22	13	102	46	--	183	259	--	259
Total Softwood	--	175	22	57	561	305	--	1,120	518	--	518
Total Hardwood	All	--	--	29	64	67	13	173	--	--	--
Total	--	175	22	86	625	372	13	1,293	518	--	518
Percent of Total	--	13.5	1.7	6.7	48.3	28.8	1.0	100.0	100.0	--	100.0

a minimum net merchantable volume of eight cunits per acre of Jack Pine, Black Spruce, White Spruce and Balsam Fir together, five inches and over in diameter at breast height. It is the best of the mature and overmature (cutting classes 4 and 5) portions of the productive area summary. Areas and volumes of cutting class 3 (intermediate) stands having a minimum net merchantable volume of eight cunits per acre of the four major species have not been included in the Net Operable Summary.

Gross Merchantable Volume

Gross Merchantable Volume estimates of wood to be lost are given in Table XXI. The Gross Merchantable Volume is the volume of all species with diameter 3.6 inches at breast height or larger and is calculated on the basis of a 12-inch stump and the following specified top diameters:

a) Jack Pine, Black Spruce and White Spruce - top diameter 3"
b) Balsam Fir, Tamarack Larch and Hardwoods - top diameter 4"

The Gross Merchantable Volume estimate indicates the total wood volume available in Intermediate, Mature and Overmature stands (cutting classes 3, 4 and 5) in the project area.

Statistical reports covering wood volume in the project area as produced by computer analysis are presented with the original report only, under separate cover in Appendices VII and VIII.

TABLE XXI

810-Foot Contour Wuskwatim Control Structure

Gross Merchantable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Limited Provincial Crown (61) M.U. 87, 89, 65, 66		
	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	24,050	5,740	29,790
Black Spruce	130,140	8,740	138,880
White Spruce	10,470	10,810	21,280
Balsam Fir	1,430	230	1,660
Tamarack Larch	530	10	540
Total Softwood	166,620	25,530	192,150
Trembling Aspen	54,360	11,200	65,560
Balsam Poplar	4,860	1,270	6,130
White Birch	7,870	550	8,420
Total Hardwood	67,090	13,030	80,110
Total	233,710	38,560	272,260

Net Merchantable Volume

Net Merchantable Volume estimates of wood to be lost in the Notigi Dam to the proposed Wuskwatim control structure are given in Table XXII. The Net Merchantable Volume is determined by applying cull factors to cover decay, breakage and harvesting loss to be expected in the area.

The following cull factors apply in the study area.

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black and White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
All Hardwoods	20%	40%

TABLE XXII

810-Foot Contour Wuskwatim Control Structure

Net Merchantable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Limited Provincial Crown (61) M.U. 87, 89, 65, 66		
	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	21,510	4,850	26,360
Black Spruce	122,400	7,780	130,180
White Spruce	9,930	9,650	19,580
Balsam Fir	1,270	180	1,450
Tamarack Larch	450	10	460
Total Softwood	155,560	22,470	178,030
Trembling Aspen	43,060	6,620	49,680
Balsam Poplar	3,810	780	4,590
White Birch	6,240	280	6,520
Total Hardwood	53,110	7,680	60,790
Total	208,670	30,150	238,820

Net Operable Volume

Net Operable Volume is determined by eliminating all trees in the four-inch diameter class and all stands which contain less than 800 cubic feet per acre of the four major softwood species (jack pine, Black spruce, white spruce and balsam fir) in cutting classes 4 and 5 only. A summary of the Net Operable Volume to be lost in the Notigi Dam to the proposed Wuskwatim control structure is given in Table XXIII. Net Operable Volume represents the volume of the best forest stands in the area.

TABLE XXIII
810-Foot Contour Wuskwatim Control Structure
Net Operable Volume Lost to Flooding*
(in Cunits)
-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Limited (61)			
	5" D.b.h.	6"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	690	4,410	1,130	6,230
Black Spruce	7,010	19,840	2,620	29,470
White Spruce	350	2,250	3,070	5,670
Balsam Fir	90	300	70	460
Total	8,140	26,800	6,890	41,830

*This summary does not include the Net Operable Volume Summary of the Hardwood Working Group.

Effect on Annual Allowable Cut

Portions of Forest Management Units 65, 66, 87 and 89 will be affected by the 810-foot contour above the proposed Wuskwatim control structure. Calculations for each of the four forest management units have been completed by the Forest Resource Inventory Section on the basis of working group and species to provide wood volumes available for harvest on a sustained yield basis. To determine the effects of flooding, the Practical Annual Cut was examined as this represents the wood volume available for use at the present time. In the original calculations a 12% reduction factor has been applied to calculated estimates to cover losses due to fire, new construction and other withdrawals from commercial harvesting operations. In examination of the area, therefore, the critical level is a 12% or greater reduction in the practical annual allowable cut.

1) Forest Management Unit 65

Productive area losses and resulting volume losses are not significant enough to affect the allowable cut.

2) Forest Management Unit 66

Numerically, the greatest volume loss was in the Black Spruce, Site I, Working Group, but on recalculation the resulting reduction in the Black Spruce annual cut was one percent. When combined with additional losses lying along the Rat River above the Notigi Dam, the reduction in the Black Spruce annual cut rises to five percent which is still well within the 12% limit.

The greatest reduction on a percentage basis occurs in the White Spruce Working Group. The reduction required dur to the proposed 810-foot contour at Wuskwatim would be 13%. When combined with additional losses above the Notigi Dam the reduction required rises approximately to 15%. A recalculation of the White Spruce annual allowable cut in this forest management unit will be required if water reaches the 810-foot contour.

The effect on the allowable cut for all other species is negligible.

3) Forest Management Unit 87

This management unit absorbes most of the volume loss caused by the flooding to the 810-foot contour at the proposed Wuskwatim control structure. Three "Status of Land" and Ownerships are involved: Manitoba Forestry Resources Limited, Private and Indian Reserve.

The greatest loss occurs in the Black Spruce Site I Working Group where a reduction of 19% would be encountered. This exceeds the guiding 12% factor and the annual allowable cut for Black Spruce must be recalculated if water reaches the 810-foot contour.

The effect on the allowable cut for all other species is negligible. There was not sufficient volume of White Spruce to calculate an allowable cut originally. Approximately 50% of the present White Spruce Net Operable Volume will be lost at the 810-foot contour.

4) Forest Management Unit 89

Productive area losses and resulting volume losses are not significant enough to affect the allowable cut.

PROPOSAL IV

Flooding to the 700-Foot Contour at the Proposed Manasan Control Structure on the Burntwood River

Area to be Lost by Flooding

Table XXV indicates the area by productivity to be lost through flooding to the 700-foot contour at the Manasan control structure.

The total land area to be lost is 41,875 acres or 65.4 square miles. Manitoba Forestry Resources Limited will lose 41,024 acres or 64.1 square miles of which 31,977 acres or 77.9 percent are classified as Forested Productive Land. The INCO area will lose 851 acres or 1.3 square miles of which 659 acres or 74.6 percent are classed as Forested Productive Land. A detailed breakdown of productive forest area only is presented in the following section under Tables XXVI and XXVII.

Statistical reports covering the project area calculations as produced by computer are presented with the original report only, under separate cover as Appendix IX and X.

Productive Forest Area

The productive forest area to be lost to flooding has been summarized and is presented in Tables XXVI and XXVII. Productive area includes the entire area of land to be lost capable of producing forest ranging from cutting class 0 (potentially productive) to cutting class 5 (overmature). Net Operable Area refers to productive area in cutting classes 4 and 5 having a minimum net merchantable volume of eight cunits per acre of Jack Pine, Black Spruce, White Spruce and Balsam Fir together, five inches and over diameter at breast height. It is the best of the mature and overmature (cutting classes 4 and 5) portions of the productive area summary. Areas and volumes of cutting class 3 (intermediate) stands having a minimum net merchantable volume of eight cunits per acre of the four major species have not been included in the Net Operable Summary.

TABLE XXIV
700-Foot Contour at the Proposed Manasan Control Structure
Area to be Flooded by Ownership and Status of Land

(in Acres)

Township	Manitoba Forestry Resources Limited Specified Area Provincial Crown (61)	INCO Provincial Crown (81)	Total Area to be Flooded
75 - 5 W	1,237	98	1,335
- 7 W	97		97
76 - 4 W	72		72
- 5 W	8,387	753	9,140
- 6 W	957		957
- 7 W	96		96
77 - 4 W	5,324		5,324
- 5 W	3,375		3,375
78 - 3 W	2,519		2,519
- 4 W	14,632		14,632
- 5 W	2,475		2,475
79 - 3 W	1,226		1,226
- 4 W	627		627
Total Area	41,024	851	41,875
Square Miles	64.1	1.3	65.4
Percent	98.0	2.0	100.0

TABLE XXV

700-Foot Contour at the Proposed Manasan Control Structure

Land Area to be Lost Through Flooding by Productivity and Status of Land

(in Acres)

Type	Manitoba Forestry Resources Limited	INCO	Total Area	%	%
	Provincial Crown (61)	Provincial Crown (81)	to be Flooded	Productivity	Total Area
Jack Pine, All Sites	5,634	273	5,907	18.1	
Black Spruce, Site I	10,935	190	11,125	34.1	
Black Spruce, Sites II & III	2,716	59	2,775	8.5	
Total Softwoods	19,285	522	19,807	60.7	--
Hardwoods	1,591	27	1,618	5.0	--
Total Forested Productive	20,876	549	21,425	65.7	--
c.c.o. Jack Pine, All Sites	5,546	--	5,546	17.0	
c.c.o. Black Spruce, Site I	4,839	110	4,949	15.1	
c.c.o. Black Spruce, Sites II & III	716	--	716	2.2	
Total Potential Productive	11,101	110	11,211	34.3	--
Total Productive	31,977	659	32,626	100.0	77.9

TABLE XXV (Cont'd)

Type	Manitoba Forestry Resources Limited	INCO	Total Area	%	%
	Provincial Crown (61)	Provincial Crown (81)	to be Flooded	Productivity	Total Area
Treed Muskeg (700)	4,793	118	4,911		
Treed Rock (710)	4		4		
Willow/Alder (720)	1,518		1,518		
Protection Forest (730)	14		14		
Total Forested Non-Productive	6,329	118	6,447	--	15.4
Marsh-Muskeg (830)	2,579	74	2,653		
Unclassified (840)	139		139		
Total Non-Forested	2,718	74	2,792	--	6.7
Grand Total Area	41,024	851	41,875	--	100.0
Square Miles	64.1	1.3	65.4	--	
Percent	98.0	2.0	100.0	--	

TABLE XXVI

700-Foot Contour at the Proposed Manasan Control Structure

Summary of Distribution of Productive Area by Working Groups and Cutting Class

Manitoba Forest Resources Limited - 61

-Provincial Crown Land Only-

Area Removed by Flooding F.M.U. 87, 89

Working Group	Site	Productive Area							Net Operable Area		
		Cutting Class									
		0	1	2	3	4	5	Total	4	5	Total
Jack Pine	All	5,546	2,471	1,120	1,662	381	--	11,180	264	--	264
Black Spruce	I	4,839	2,383	2,450	5,437	658	7	15,774	509	7	516
Black Spruce	II & III	716	1,055	644	933	84	--	3,432	--	--	--
Total Softwood	--	11,101	5,909	4,214	8,032	1,123	7	30,386	773	7	780
Hardwood	All	--	201	429	759	202	--	1,591	--	--	--
Total		11,101	6,110	4,643	8,791	1,325	7	31,977	773	7	780
Percent of Total		34.7	19.1	14.5	27.5	4.2	--	100.0	99.1	8.9	100.0

TABLE XXVII

700-Foot Contour at the Proposed Manasan Control Structure

Summary of Distribution of Productive Area by Working Groups and Cutting Class

(in Acres)

-Provincial Crown Land Only-

INCO 81

Area Removed by Flooding, M.U. 87, 89

Working Group	Productive Area							
	Site	Cutting Class						
		0	1	2	3	4	5	Total
Jack Pine	I	--	--	160	113	--	--	273
Black Spruce	I	110	16	81	93	--	--	300
Black Spruce	II	--	33	--	26	--	--	59
Total Softwood		110	49	241	232	--	--	632
Hardwood	All	--	11	--	16	--	--	27
Total		110	60	241	248	--	--	659
Percent of Total		16.7	9.1	36.6	37.6	--	--	100.0

Gross Merchantable Volume

Gross Merchantable Volume estimates of wood to be lost are given in Table XXVIII. The Gross Merchantable Volume is the volume of all species with diameter 3.6 inches at breast height or larger and is calculated on the basis of a 12-inch stump and the following specified top diameters:

a) Jack Pine, Black Spruce and White Spruce - top diameter 3"

b) Balsam Fir, Tamarack Larch and Hardwoods - top diameter 4"

The Gross Merchantable Volume estimate indicates the total wood volume available in Intermediate, Mature and Overmature stands (cutting classes 3, 4 and 5) in the project area.

Statistical reports covering wood volume in the project area as produced by computer analysis are presented with the original report only, under separate cover in Appendices IX and X.

TABLE XXVIII

700-Foot Contour at the Proposed Manasan Control Structure

Gross Merchantable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Ltd. Provincial Crown (61) M.U. 87, 89			INCO Provincial Crown (81) M.U. 87, 89			Total Flood Area		
	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	18,210	3,380	21,590	790	60	850	19,000	3,440	22,440
Black Spruce	54,930	3,400	58,330	1,100	80	1,180	56,030	3,480	59,510
White Spruce	2,050	2,100	4,150	20	30	50	2,070	2,130	4,200
Balsam Fir	260	20	280	--	--	--	260	20	280
Tamarack Larch	250	--	250	--	--	--	250	--	250
Total Softwood	75,700	8,900	84,600	1,910	170	2,080	77,610	9,070	86,680
Trembling Aspen	14,950	2,280	17,230	440	50	490	15,390	2,330	17,720
Balsam Poplar	1,700	280	1,980	30	--	30	1,730	280	2,010
White Birch	2,460	120	2,580	50	--	50	2,510	120	2,630
Total Hardwood	19,110	2,680	21,790	520	50	570	19,630	2,730	22,360
Total	93,810	11,580	106,390	2,430	220	2,650	97,240	11,800	109,040

Net Merchantable Volume

Net Merchantable Volume estimates of wood to be lost in the Wuskwatim to Manasan Project Area are given in Table XXIX. The Net Merchantable Volume is determined by applying cull factors to cover decay, breakage and harvesting loss to be expected in the area. The following cull factors apply in the study area.

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black and White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
All Hardwoods	20%	40%

TABLE XXIX

700-Foot Contour at the Proposed Manasan Control Structure

Net Merchantable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Ltd. Provincial Crown (61) M.U. 87, 89			INCO Provincial Crown (81) M.U. 87, 89			Total Flood Area		
	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	16,260	2,810	19,070	700	60	760	16,960	2,870	19,830
Black Spruce	51,580	3,070	54,650	1,010	60	1,070	52,590	3,130	55,720
White Spruce	1,910	1,900	3,810	20	30	50	1,930	1,930	3,860
Balsam Fir	240	20	260	--	--	--	240	20	260
Tamarack Larch	210	--	210	--	--	--	210	--	210
Total Softwood	70,200	7,800	78,000	1,730	150	1,880	71,930	7,950	79,880
Trembling Aspen	11,860	1,370	13,230	310	80	390	12,170	1,450	13,620
Balsam Poplar	1,330	140	1,470	20	--	20	1,350	140	1,490
White Birch	1,920	70	1,990	40	--	40	1,960	70	2,030
Total Hardwood	15,110	1,580	16,690	370	80	450	15,480	1,660	17,410
Total	85,310	9,380	94,690	2,100	230	2,330	87,410	9,610	97,020

Net Operable Volume

Net Operable Volume is determined by eliminating all trees in the 4-inch diameter class and all stands which contain less than eight cunits per acre of the four major softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) in cutting classes 4 and 5 only. A summary of the Net Operable Volume to be lost in the Wuskwatim to Manasan area is given in Table XXX. Net Operable Volume represents the volume of the best forest stands in the area.

TABLE XXX

700-Foot Contour at the Proposed Manasan Control Structure

Net Operable Volume Lost to Flooding*

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Limited - 61			
	5" D.b.h.	6"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	230	1,950	600	2,780
Black Spruce	1,070	3,540	560	5,170
White Spruce	10	250	370	630
Balsam Fir	10	30	10	50
Total	1,320	5,770	1,540	8,630

*This summary does not include the Net Operable Volume Summary of the Hardwood Working Group.

Effect on Annual Allowable Cut

Portions of two forest management units (87 and 89) are affected by flooding in this proposal. Calculations for each of the two management units were made by the Forest Resource Inventory Section on the basis of Working Group and Species to provide wood volumes available for harvest on a sustained yield basis. To determine the effects of flooding, the Practical Annual Allowable Cut was examined as this calculation gave the volume available for future disposition. In the original calculations a 12% reduction factor has been applied to calculated estimates to cover losses due to fire, new construction and withdrawals from commercial harvesting operations. In examination of the area, therefore, the critical level is a 12% or greater reduction in the annual allowable cut. Management Unit 87 was most affected.

1) Forest Management Unit 87

This management unit has two status of Provincial Crown Land within it: Manitoba Forestry Resources Limited and International Nickel Company Limited. Volume loss of Black Spruce was more than any other species. Recalculation shows that this portion of the flooding will reduce the allowable annual cut in the Black Spruce Site I Working Group of Management Unit 87 by four percent. This in itself is not significant being well within the 12% factor built into the original allowable cut calculations but the flooding above the Wuskwatim control strucutre within Forest Management Unit 87 will result in a further 19% reduction in the same working group. The combined loss, approximately 22% is then considerably in excess of the 12% loss factor so a recalculation of the allowable cut will be required and a reduction in available volume will result if water reaches the 810-foot contour above Wuskwatim and the 700-foot contour at Manasan.

2) Forest Management Unit 89

Forest Management Unit 89 will be affected only by the extreme northern part of the flooding from the Wuskwatim and Manasan structures. This will result in a small volume and productive area loss, but will not require a change in the allowable cut.

PROPOSAL V

Diversion Flooding from Notigi to Wuskwatim with No Control Structure at the Wuskwatim Site

Area to be Lost by Flooding

The land area to be lost through diversion only between Notigi and the Wuskwatim site at Taskinigup Falls on the Burntwood River has been calculated to be 39,771 acres or 62.1 square miles. The total land area involved has been summarized and is presented in the following section in Table XXXI.

Statistical reports covering the project area calculations as produced by computer are presented with the original report only. Area summaries for a portion of the area lying between Notigi and Range 11 West of the Principal Meridian are included as part of Appendix VII as the areas to be flooded in this portion of the project area. They are identical regardless whether or not a control structure is built at the Wuskwatim site. The remaining portion of the project area lying between Range 10 West and the Notigi site are listed under separate cover as Appendices XI and XII.

Manitoba Forestry Resources Limited will lose 37,785 acres or 59.0 square miles of which 15,216 acres or 40% are classed as Forested Productive Land. Indian Reserves will lose 1,970 acres or 3.1 square miles of which 1,293 acres or 65.6% are classified as Forested Productive Land. Private land owners will lose 16 acres, none of which is Forested Productive. The area of Private Land and Indian Reserve Land to be flooded to the 810-foot contour (Proposal III) and Diversion alone are identical.

TABLE XXXI

Diversion Route Notigi to Wuskwatim Site

No Control Structure at Wuskwatim

Area to be Flooded by Ownership and Status of Land

(in Acres)

Township	Manitoba Forestry Resources Ltd. Specified Area Provincial Crown Land (61)	Patent (Private) (65)	Indian Reserve (67)	Total Area to be Flooded
74-11 WPM	44			44
75- 8 WPM	2,729			2,729
- 9	1,019			1,019
-11	363			363
76- 7 WPM	404			404
- 8	1,505			1,505
- 9	24			24
-11	395			395
77- 7 WPM	1,146			1,146
- 8	1,470			1,470
- 9	3,105			3,105
-10	4,325			4,325
-11	2,478			2,478
-12	771			771
78- 8 WPM	798			798
- 9	1,084	16	303	1,403
-10	804		1,417	2,221
-11	1,732			1,732
-12	2,966			2,966
-13	318			318
79- 9 WPM	1,455		219	1,674
-10	1,421		31	1,452
-11	1,244			1,244
-12	1,548			1,548
-13	67			67
80-10 WPM	2,370			2,370
-11	635			635
81-10 WPM	1,565			1,565
Total Area	37,785	16	1,970	39,771
Square Miles	59.0	--	3.1	62.1
Percent	95.0	--	5.0	100.0

Productive Forest Area

The productive forest area to be lost to flooding has been summarized and is presented in Tables XXXII, XXXIII and XXXIV. Productive area includes the entire area of land to be lost capable of producing forest ranging from cutting class 0 (potentially productive) to cutting class 5 (overmature). Net Operable Area refers to productive area in cutting classes 4 and 5 having a minimum net merchantable volume of eight cunits per acre of Jack Pine, Black Spruce, White Spruce and Balsam Fir together, five inches and over in diameter at breast height (D.b.h.). It is the best of the mature and overmature (cutting classes 4 and 5) portions of the productive area summary. Areas and volumes of cutting class 3 (intermediate) stands having a minimum net merchantable volume of eight cunits per acre of the four major softwood species have not been included in the Net Operable Summary.

Gross Merchantable Volume

Gross Merchantable Volume estimates of wood to be lost through flooding due to diversion only between Notigi and Wuskwatim are given in Tables XXXV and XXXVI. The Gross Merchantable Volume is the volume of all species with diameter 3.6 inches at breast height or larger and is calculated on the basis of a 12-inch stump and the following specified top diameters:

a) Jack Pine, Black Spruce and White Spruce - top diameter 3"

b) Balsam Fir, Tamarack Larch and Hardwoods - top diameter 4"

The Gross Merchantable Volume estimate indicates the total wood volume available in Intermediate, Mature and Overmature stands (cutting classes 3, 4 and 5) in the project area.

Statistical reports covering wood volume in the project area as produced by computer analysis are presented with the original report only, under separate cover in Appendices XI and XII.

TABLE XXXII

Diversion Route Notigi to Wuskwatim Site

No Control Structure at Wuskwatim

Area to be Lost Through Flooding by Productivity and Status of Land

(in Acres)

Type	Manitoba Forestry Resources Limited Provincial Crown (61)	Patent (65)	Indian Reserve (67)	Total Area to be Flooded	% Productive	% Total Area
Jack Pine, All Sites	1,350		44	1,394	6.5	
Black Spruce, Site I	8,557		718	9,275	43.1	
Black Spruce, Sites II & III	1,373		183	1,556	7.2	
White Spruce, All Sites	228		--	228	1.1	
Tamarack Larch, All Sites	21		--	21	0.1	
Total Softwoods	11,529	--	945	12,474	58.0	--
Hardwoods	3,687	--	173	3,860	18.0	
Total Forested Productive	15,216	--	1,118	16,334	76.0	

TABLE XXXII (Cont'd)

Type	Manitoba Forestry Resources Limited Provincial Crown (61)	Patent (65)	Indian Reserve (67)	Total Area to be Flooded	% Productive	% Total Area
c.c.o. Jack Pine, All Sites	928		6	934	4.3	
c.c.o. Black Spruce, Site I	2,744		169	2,913	13.6	
c.c.o. Black Spruce, Sites II & III	1,317		--	1,317	6.1	
Total Potential Productive	4,989	--	175	5,164	24.0	--
Total Productive	20,205	--	1,293	21,498	100.0	54.1
Treed Muskeg (700)	7,587		184	7,771		
Treed Rock (710)	30		--	30		
Willow/Alder (720)	5,546		184	5,730		
Protection Forest (730)	152		--	152		
Total Forested Non-Productive	13,315	--	368	13,683	--	34.4

TABLE XXXII (Cont'd)

Type	Manitoba Forestry Resources Limited Provincial Crown (61)	Patent (65)	Indian Reserve (67)	Total Area to be Flooded	% Productive	% Total Area
Marsh-Muskeg (830)	3,939		239	4,178		
Unclassified (840)	326	16	70	412		
Total Non-Forested	4,265	16	309	4,590	--	11.5
Grand Total Area	37,785	16	1,970	39,771	--	100.0
Square Miles	59.0	--	3.1	62.1	--	
Percent	95.0	--	5.0	100.0	--	

TABLE XXXIII

Diversion Only, Notigi to Wuskwatim Site

Summary of Distribution of Productive Area by Working Groups and Cutting Class

-Provincial Crown Land Only-

(in Acres)

Manitoba Forestry Resources Limited (61)

Area Removed by Flooding, M.U. 65, 66, 87, 89

Working Group	Productive Area								Net Operable Area		
	Site	Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	All	928	381	638	286	45	--	2,278	45	--	45
Black Spruce	I	2,744	601	1,548	4,963	1,406	39	11,301	1,341	33	1,374
Black Spruce	II & III	1,317	178	290	818	87	--	2,690	--	--	--
White Spruce	All	--	--	--	119	109	--	228	99	--	99
Tamarack Larch	All	--	--	21	--	--	--	21	--	--	--
Total Softwood		4,989	1,160	2,497	6,186	1,647	39	16,518	1,485	33	1,518
Total Hardwood		--	206	649	1,840	960	32	3,687	--	10	10
Total		4,989	1,366	3,146	8,026	2,607	71	20,205	1,485	43	1,528
Percent of Total		24.7	6.8	15.6	39.7	12.9	0.3	100.0	97.2	2.8	100.0

TABLE XXXIV

Diversion Only, Notigi to Wuskwatim Site

Summary of Distribution of Productive Area by Working Group and Cutting Class

(in Acres)

Manitoba Forestry Resources Limited 67

-Indian Reserve Land-

Area Removed by Flooding, M.U. 87, 89

Working Group	Productive Area								Net Operable Area		
	Site	Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	I	6	--	--	21	23	--	50	23	--	23
Black Spruce	I	169	--	44	438	236	--	887	236	--	236
Black Spruce	II & III	--	22	13	102	46	--	183	--	--	--
Total Softwood		175	22	57	561	305	--	1,120	259	--	259
Total Hardwood		--	--	29	64	67	13	173	--	--	--
Total		175	22	86	625	372	13	1,293	259	--	259
Percent of Total		13.5	1.7	6.7	48.3	28.8	1.0	100.0	100.0	--	100.0

TABLE XXXV

Diversion Only, Notigi to Wuskwatim Site

Gross Merchantable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Limited Provincial Crown (61) M.U. 65, 66, 87, 89		
	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	8,010	2,370	10,380
Black Spruce	66,360	4,540	70,900
White Spruce	6,350	6,320	12,670
Balsam Fir	750	100	850
Tamarack Larch	140	--	140
Total Softwood	81,610	13,330	94,940
Trembling Aspen	30,370	7,140	37,510
Balsam Poplar	2,350	780	3,130
White Birch	4,080	290	4,370
Total Hardwood	36,800	8,210	45,010
Total	118,410	21,540	139,950

TABLE XXXVI

Diversion Only, Notigi to Wuskwatim Site

Gross Merchantable Volume Lost to Flooding

(in Cunits)

-Indian Reserve Land - (67)-

Species	Manitoba Forestry Resources Ltd. Indian Reserve (67) M.U. 65, 66, 87, 89		
	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	930	140	1,070
Black Spruce	8,490	460	8,950
White Spruce	390	410	800
Balsam Fir	60	10	70
Tamarack Larch	--	--	--
Total Softwood	9,870	1,020	10,890
Trembling Aspen	1,770	440	2,210
Balsam Poplar	100	90	190
White Birch	280	10	290
Total Hardwood	2,150	540	2,690
Total	12,020	1,560	13,580

Net Merchantable Volume

The net merchantable volume estimates of wood to be lost along the diversion route between the Notigi dam and the Wuskwatim site with no control structure at Wuskwatim are given in Tables XXXVII and XXXVIII. The net merchantable volume is determined by applying cull factors to cover decay, breakage and harvesting loss to be expected in the area.

The following cull factors apply to the study area.

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black and White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
All Hardwoods	20%	40%

TABLE XXXVII

Diversion Only, Notigi to Wuskwatim Site

Net Merchantable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Limited Provincial Crown (61) M.U. 65, 66, 87, 89		
	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	7,180	2,010	9,190
Black Spruce	62,410	4,030	66,440
White Spruce	5,930	5,630	11,560
Balsam Fir	590	80	670
Tamarack Larch	120	--	120
Total Softwood	76,230	11,750	87,980
Trembling Aspen	24,020	4,220	28,240
Balsam Poplar	1,830	490	2,320
White Birch	3,200	170	3,370
Total Hardwood	29,050	4,880	33,930
Total	105,280	16,630	121,910

TABLE XXXVIII

Diversion Only, Notigi to Wuskwatim Site

Net Merchantable Volume Lost to Flooding

(in Cunits)

Indian Reserve Land

Species	Manitoba Forestry Resources Limited Indian Reserve (67) M.U. 65, 66, 87, 89		
	4"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	790	120	910
Black Spruce	7,930	400	8,330
White Spruce	380	360	740
Balsam Fir	50	20	70
Tamarack Larch	--	--	--
Total Softwood	9,150	900	10,050
Trembling Aspen	1,400	230	1,630
Balsam Poplar	120	30	150
White Birch	200	10	210
Total Hardwood	1,720	270	1,990
Total	10,870	1,170	12,040

Net Operable Volume

Net operable volume is determined by eliminating all trees in the four-inch diameter class and all stands which contain less than 800 cubic feet per acre of the four major softwood species (jack pine, black spruce, white spruce and balsam fir) in Cutting Classes 4 and 5 only. A summary of the net operable volume to be lost to flooding along the diversion route with no control structure at Wuskwatim is given in Tables XXXIX and XL. Net operable volume represents the volume of the best forest stands in the area.

TABLE XXXIX

Diversion Only, Notigi to Wuskwatim Site

Net Operable Volume Lost to Flooding

(in Cunits)

-Provincial Crown Land Only-

Species	Manitoba Forestry Resources Limited - 61			
	5" D.b.h.	6"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	240	1,490	410	2,140
Black Spruce	3,260	9,370	1,260	13,890
White Spruce	210	1,250	1,740	3,200
Balsam Fir	20	140	20	180
Total	3,730	12,250	3,430	19,410

TABLE XL

Diversion Only, Notigi to Wuskwatim Site

Net Operable Volume Lost to Flooding

(in Cunits)

Indian Reserve Land

Species	Manitoba Forestry Resources Limited - 67			
	5" D.b.h.	6"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	50	310	60	420
Black Spruce	660	1,770	220	2,650
White Spruce	20	130	140	290
Balsam Fir	10	20	10	40
Total	740	2,230	430	3,400

Effect on Annual Allowable Cut

Portions of Forest Management Units 65, 66, 87 and 89 will be affected by diversion only above the proposed Wuskwatim site. Calculations for each of the four forest management units have been completed by the Forest Resource Inventory Section on the basis of working group and species to provide wood volumes available for harvest on a sustained yield basis. To determine the effects of flooding, the Practical Annual Cut was examined as this represents the wood volume available for use at the present time. In the original calculations a 12% reduction factor has been applied to calculated estimates to cover losses due to fire, new construction and other withdrawals from commercial harvesting operations. In examination of the area, therefore, the critical level is a 12% or greater reduction in the practical annual allowable cut.

1) Forest Management Unit 65

Productive area losses and resulting volume losses are not significant enough to affect the allowable cut.

2) Forest Management Unit 66

Numerically, the greatest volume loss was in the Black Spruce, Site I, Working Group, but on recalculation the resulting reduction in the Black Spruce annual cut was less than 1%. When combined with additional losses lying along the Rat River above the Notigi Dam, the reduction in the Black Spruce annual cut rises to 5% which is still well within the 12% limit.

The greatest reduction on a percentage basis occurs in the White Spruce Working Group. The reduction required due to the proposed diversion only above Wuskwatim would be 9%. When combined with additional losses above the Notigi Dam the reduction required rises to 11%. Any additional flooding would require a recalculation of the White Spruce annual allowable cut in this forest management unit.

The effect on the allowable cut for all other species is negligible.

3) Forest Management Unit 87

This management unit absorbes most of the loss caused by the flooding by diversion only above the Wuskwatim site. Three "Status of Land" and Ownerships are involved: Manitoba Forestry Resources Limited, Private and Indian Reserve.

The greatest loss occurs in the Black Spruce Site I Working Group where a reduction of 11% would be encountered. This is just within the guiding 12% factor.

The effect on the allowable cut for all other species is negligible.

4) Forest Management Unit 89

Productive area losses and resulting volume losses are not significant enough to affect the allowable cut.

PROPOSAL VI

Diversion Flooding Wuskwatim to Manasan With No Control Structure at the Manasan Site

Area to be Lost by Flooding

Table XLI indicates the area to be lost through flooding along the diversion route lying between the Wuskwatim site and the Manasan site with no control structures.

The total land area to be lost is 4,030 acres or 6.3 square miles. Manitoba Forestry Resources Limited will lose 4,030 acres or 6.3 square miles of which 1,937 acres or 48 percent are classified as Forested Productive Land.

TABLE XLI

Diversion Only Between the Wuskwatim Site and the Manasan Site with No Control Structures

Area to be Flooded by Ownership and Status of Land

(in Acres)

Township	Manitoba Forestry Resources Limited Specified Area Provincial Crown Land (61)
76 - 5 WPM	479
77 - 4 WPM	221
- 5	2,062
78 - 3 WPM	191
- 4	1,039
79 - 3 WPM	33
- 4	5
Total Area	4,030
Square Miles	6.3
Percent	100.0

A detailed breakdown of productive forest area is presented in the following section in Table XLII.

Statistical reports covering the project area calculations as produced by computer are presented with the original report only, under separate cover as Appendices XIII and XIV.

Productive Forest Area

The productive forest area to be lost to flooding by diversion only has been summarized and is presented in Table XLIII. Productive area includes the entire area of land to be lost capable of producing forest ranging from cutting class 0 (potentially productive) to cutting class 5 (overmature). Net Operable Area refers to productive area in cutting classes 4 and 5 with a minimum net merchantable volume of eight cunits per acre of Jack Pine, Black Spruce, White Spruce and Balsam Fir together, five inches and over diameter at breast height (D.b.h.). It is the best of the mature and overmature (cutting classes 4 and 5) portions of the productive area summary. Areas and volumes of cutting class 3 (intermediate) stands with a minimum net merchantable volume of eight cunits per acre of the four major softwood species have not been included in the Net Operable Summary.

TABLE XLII

Diversion Only, Wuskwatim Site to Manasan Site

Land Area to be Lost Through Flooding by Productivity and Status of Land

(in Acres)

Type	Manitoba Forestry Resources Limited Provincial Crown (61)	Total Area	% Productivity	% Total Area
Jack Pine, All Sites	394	394	14.6	
Black Spruce, Site I	1,135	1,135	42.1	
Black Spruce, Site II	282	282	10.5	
Total Softwoods	1,811	1,811	67.2	--
Hardwoods	126	126	4.7	--
Total Forested Productive	1,937	1,937	71.9	--
c.c.o. Jack Pine, All Sites	380	380	14.1	
c.c.o. Black Spruce, Site I	357	357	13.2	
c.c.o. Black Spruce, Site II	21	21	0.8	
Total Potential Productive	758	758	28.1	--
Total Productive	2,695	2,695	100.0	67.0
Treed Muskeg (700)	435	435		
Willow and Alder (720)	560	560		
Total Forested Non-Productive	995	995	--	25.0

TABLE XLII (Cont'd)

Type	Manitoba Forestry Resources Limited Provincial Crown (61)	Total Area	% Productivity	% Total Area
Marsh, Muskeg (830)	339	339		
Unclassified (840)	1	1		
Total Non-Forested	340	340	--	8.0
Grand Total Area	4,030	4,030	--	100.0
Square Miles	6.3	6.3		
Percent	100.0	100.0		

TABLE XLIII

Diversion Only - Wuskwatim Site to the Manasan Site

Summary of Distribution of Productive Area by Working Groups and Cutting Class

Manitoba Forestry Resources Limited - 61

-Provincial Crown Land Only-

Area Removed by Flooding in F.M.U. 87 & 89

Working Group	Site	Productive Area							Net Operable Area		
		Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	All	380	116	127	127	24	--	774	9	--	9
Black Spruce	I	357	294	411	359	68	3	1,492	19	3	22
Black Spruce	II	21	37	71	128	46	--	303	--	--	--
Total Softwood		758	447	609	614	138	3	2,569	28	3	31
Hardwood		--	10	24	85	7	--	126	--	--	--
Total		758	457	633	699	145	3	2,695	28	3	31
Percent of Total		28.1	17.0	23.5	25.9	5.4	0.1	100.0	90.3	9.7	100.0

Gross Merchantable Volume

Gross Merchantable Volume estimates of wood to be lost through flooding due to diversion only, between Wuskwatim and Manasan sites are given in Table XLIV. The Gross Merchantable Volume is the volume of all species with diameter 3.6 inches at breast height or larger and is calculated on the basis of a 12-inch stump and the following specified top diameters:

a) Jack Pine, Black Spruce and White Spruce - top diameter 3"

b) Balsam Fir, Tamarack Larch and Hardwoods - top diameter 4"

The Gross Merchantable Volume estimate indicates the total wood volume available in Intermediate, Mature and Overmature stands (cutting classes 3, 4 and 5) in the project area.

Statistical reports covering wood volume in the project area as produced by computer analysis are presented with the original report only, under separate cover in Appendices XIII and XIV.

TABLE XLIV

Diversion Only - Wuskwatim Site to Manasan Site

Gross Merchantable Volume Lost to Flooding

(in Cunits)

Manitoba Forestry Resources - 61

-Provincial Crown Land Only-

Species	4"-9" D.b.h.	10"+ D.b.h.	Total Flood Area
Jack Pine	1,080	240	1,320
Black Spruce	4,250	270	4,520
White Spruce	70	150	220
Tamarack Larch	10	--	10
Total Softwood	5,410	660	6,070
Trembling Aspen	1,250	180	1,430
Balsam Poplar	120	40	160
White Birch	100	--	100
Total Hardwood	1,470	220	1,690
Total	6,880	880	7,760

Net Merchantable Volume

The Net Merchantable Volume estimates of wood to be lost along the diversion route between the Wuskwatim site location and the Manasan site location with no control structures at Manasan are given in Table XLV. The net merchantable volume is determined by applying cull factors to cover decay, breakage and harvesting loss to be expected in the area.

The following cull factors apply to the study area:

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black and White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
All Hardwoods	20%	40%

TABLE XLV

Diversion Only - Wuskwatim Site to Manasan Site

Net Merchantable Volume Lost to Flooding

(in Cunits)

Manitoba Forestry Resources Limited - 61

-Provincial Crown Land Only-

Species	4"-9" D.b.h.	10"+ D.b.h.	Total Flood Area
Jack Pine	1,000	200	1,200
Black Spruce	3,980	240	4,220
White Spruce	70	130	200
Total Softwood	5,050	570	5,620
Trembling Aspen	970	90	1,060
Balsam Poplar	90	20	110
White Birch	90	--	90
Total Hardwood	1,150	110	1,260
Total	6,200	680	6,880

Net Operable Volume

Net Operable Volume is determined by eliminating all trees in the four-inch diameter class and all stands which contain less than 800 cubic feet per acre of the four major softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) in cutting classes 4 and 5 only. A summary of the Net Operable Volume to be lost to flooding along the diversion route with no control structure at Manasan is given in Table XLVI. Net Operable Volume represents the volume of the best forest stands in the area.

TABLE XLVI

Diversion Only - Wuskwatim Site to Manasan Site

Net Operable Volume Lost to Flooding*

(in Cunits)

Manitoba Forestry Resources Limited - 61

-Provincial Crown Land Only-

Species	5" D.b.h.	6"-9" D.b.h.	10"+ D.b.h.	Total
Jack Pine	10	50	30	90
Black Spruce	30	120	20	170
White Spruce	--	--	10	10
Total	40	170	60	270

*Excludes Hardwood Volumes.

Effect on Annual Allowable Cut

The volumes and areas to be lost through flooding due to diversion alone between the Wuskwatim site and Manasan site are not sufficient to have an effect on the annual allowable cut of Forest Management Units 87 or 89.

Timber Clearing

All trees which are within the area to be flooded will be killed. To minimize dollar losses, the merchantable volume to be lost should be salvaged and utilized commercially.

The area to be affected by flooding, regardless of degree, lies within the specified area of Manitoba Forestry Resources Limited. The settlement, private land and Indian Reserve land at Nelson House are within the area which will be flooded between Notigi and the Wuskwatim site. The Nelson House area will have an important bearing on timber clearing through provision of a labour supply and community-related problems.

For forestry purposes alone, complete clearing of all trees on areas to be flooded is not necessary. Commercially, valuable stands of trees to be flooded should be harvested, if at all possible, for utilization in Hydro construction projects, boom timber for debris control and local construction needs at Nelson House and Thompson.

Beneficial Effects

There are few apparent beneficial effects for forestry in the area accruing directly from the flooding operation. The construction of all-weather roads from Provincial Highway 391 to the proposed control structures at Wuskwatim and Manasan will improve accessibility. Timber harvesting and clearing will give some short-term benefits in the form of work for men employed in these operations and benefits in the form of saleable forest products.

Detrimental Effects

The primary detrimental effect on forestry is the loss of productive forest land and the present or future volumes of wood that these productive lands support. The loss of land and volume in turn reduces the amount of wood available for harvest on an annual basis. The initial impact of these losses on the annual allowable cut will be minimized if the merchantable wood volume to be lost by flooding canbe salvaged and utilized. This volume could then be considered as the annual allowable cut for the initial period of harvesting in the forest management unit with the result that volume losses could be spread over a 20 or 30-year period.

The allowable annual cut will be decreased for all species when the exact extent of flooding is known upon completion of the project. The White Spruce Working Group suffers most severely on a percentage basis because its requirements for good soil and drainage places it on lake shores and river banks where the effects of flooding will be most severe.

The greatest volume loss in Forest Management Units 66, 87 are in the Black Spruce Site I Working Group. Forests located in Forest Management Units 65 and 89 are only marginally affected.

Conclusions

Between the Notigi control structure and proposed Wuskwatim control strucutre there will be a loss of considerable wood volume if the area is flooded without harvest. Significant flooding with respect to forest cover and the Nelson House Settlement will occur regardless whether a control structure is built at the Wuskwatim site or not. Sufficient land area and wood volume will be lost to reduce the annual allowable cuts for

White Spruce in Forest Management Unit 66 and Black Spruce in Forest Management Unit 89.

The following summary of losses to be expected through the various proposals is presented for simple comparison purposes.

Proposal	Total Area Loss in Acres				Gross Merchantable Volume Loss (in Cunits)* On Provincial Crown Land Only	Net Merchantable Volume Loss (in Cunits)* On Provincial Crown Land Only	Net Operable Volume Loss (in Cunits)* On Provincial Crown Land Only
	Provincial Crown	Patent	Indian Reserve	Total Area			
I 800-foot Contour* at Wuskwatim	52,501	7	1,149	53,657	149,380	130,720	21,040
II 690-foot Contour at Manasan	31,933	--	--	31,933	84,170	75,050	6,060
III 810-foot Contour at Wuskwatim	78,234	16	1,970	80,220	272,260	238,820	41,830
IV 700-foot Contour	41,875	--	--	41,875	109,040	97,020	8,630
V Diversion Only Notigi to Wuskwatim	37,785	16	1,970	39,771	139,950	121,910	19,410
VI Diversion Only Wuskwatim to Manasan	4,030	--	--	4,030	7,760	6,880	270

*Proposal I - 800-foot contour at Wuskwatim is included for information only as it was calculated before water levels were detailed. This contour will be exceeded at all times due to the volume of water moving through the diversion route and a natural control located near Caribou Falls on the Burntwood River.

An analysis of Gross Merchantable Volume for each of the proposals follows to allow comparison of volumes to be lost by species and broad diameter classes.

Proposal	Location	Gross Merchantable Volume in Cunits											
		Jack Pine	Black Spruce	White Spruce	Balsam Fir	Tamarack Larch	Trembling Aspen	Balsam Poplar	White Birch	Total	4"-9" Diameter	10"+ Diameter	Total
I	800' Contour at Wuskwatim	15,080	75,350	12,410	1,020	220	37,190	3,410	4,700	149,380	127,940	21,440	149,380
II	690' Contour at Manasan	17,420	46,630	3,160	170	190	13,080	1,540	1,980	84,170	75,270	8,900	84,170
III	810' Contour at Wuskwatim	29,790	138,880	21,280	1,660	540	65,560	6,130	8,420	272,260	233,710	38,560	272,260
IV	700' Contour at Manasan	22,440	59,510	4,200	280	250	17,720	2,010	2,630	109,040	97,240	11,800	109,040
V	Diversion Only Notigi to Wuskwatim Site	10,380	70,900	12,670	850	140	37,510	3,130	4,370	139,950	118,410	21,540	139,950
VI	Diversion Only Wuskwatim to Manasan	1,320	4,520	220	--	10	1,430	160	100	7,760	6,880	880	7,760

The following summary indicates the loss of Net Operable Volume for the four major softwood species (jack pine, black spruce, white spruce and balsam fir). This summary allows comparison of diameter distribution and volumes to be lost through the various flooding proposals.

Proposal	Location	Net Operable Volume - Major Softwood Species in Cunits and Percent							
		5"		6"-9"		10"+		Total	
I	800' Contour at Wuskwatim	4,090	20%	13,330	63%	3,620	17%	21,040	100%
II	690' Contour at Manasan	960	16%	4,080	67%	1,020	17%	6,060	100%
III	810' Contour at Wuskwatim	8,410	19%	26,800	64%	6,890	17%	41,830	100%
IV	700' Contour at Manasan	1,320	15%	5,770	67%	1,540	18%	8,630	100%
V	Diversion Only Notigi to Wuskwatim	3,730	19%	12,250	63%	3,430	18%	19,410	100%
VI	Diversion Only Wuskwatim to Manasan	40	15%	170	63%	60	22%	270	100%

Harvest of merchantable wood in the flood zone is advised wherever possible. Some large white spruce timbers may be required for boom logs in retention of floatage after flooding. The rest of the white spruce and jack pine, and possible some black spruce and trembling aspen, of sufficient size and quality are best used as sawlogs. Some lumber will be needed for construction during the project and the rest could be used locally or sent to other markets by rail. Any Net Operable Volume for Softwood in trees of merchantable size, but not suitable for sawlogs should be sent to the Manitoba Forestry Resources mill at The Pas for pulpwood. Additional clearing may be necessary in critical sectors whether or not the stand is merchantable.

APPENDIX 3 - E

FOREST RESOURCE INVENTORY OF THE AREA BETWEEN THE 850-FOOT ELEVATION CONTOUR AND SOUTHERN INDIAN LAKE

FOREST RESOURCE INVENTORY OF THE AREA BETWEEN THE 850-FOOT ELEVATION CONTOUR AND SOUTHERN INDIAN LAKE

by

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Winnipeg, Manitoba
January, 1973

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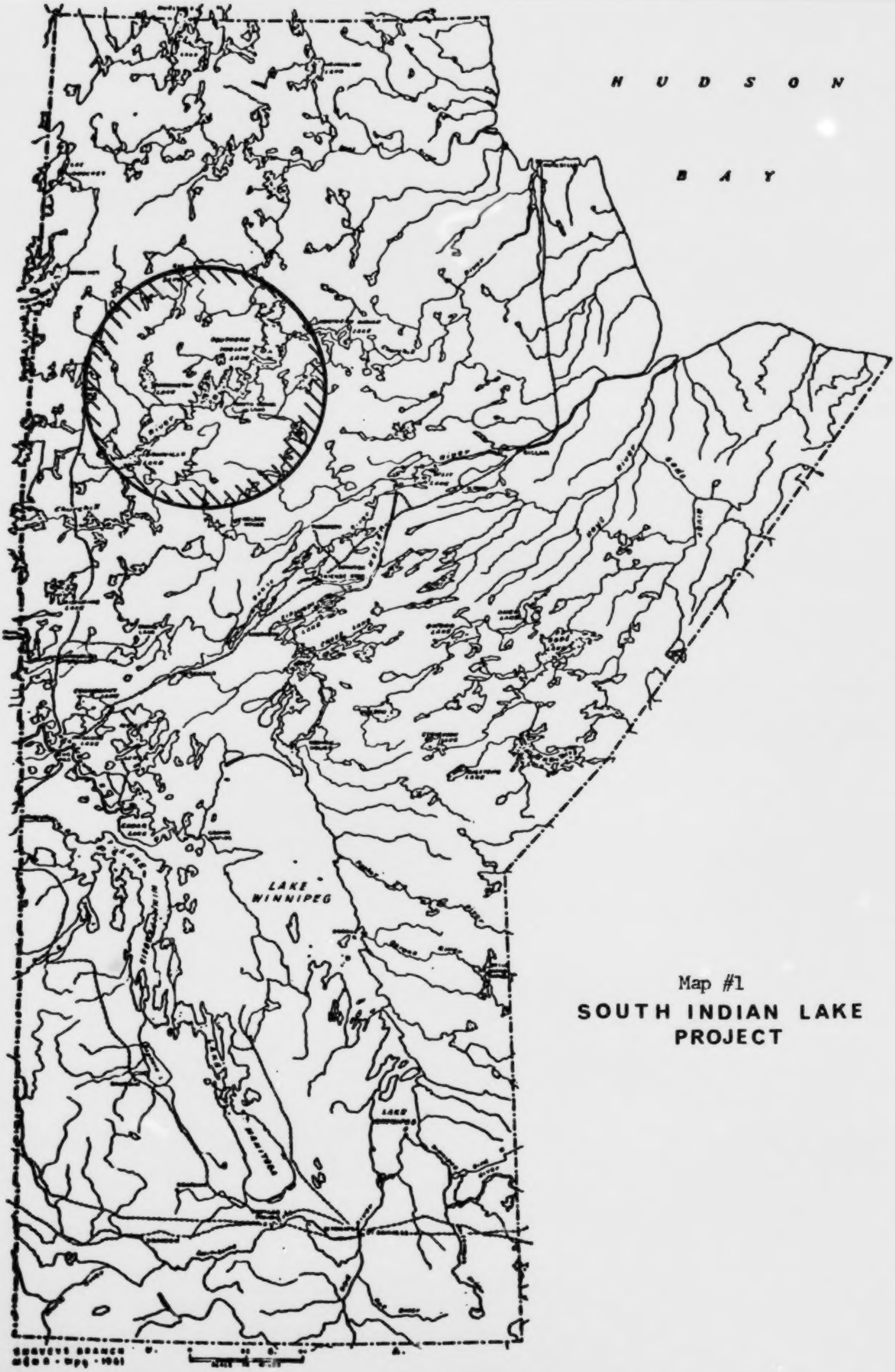
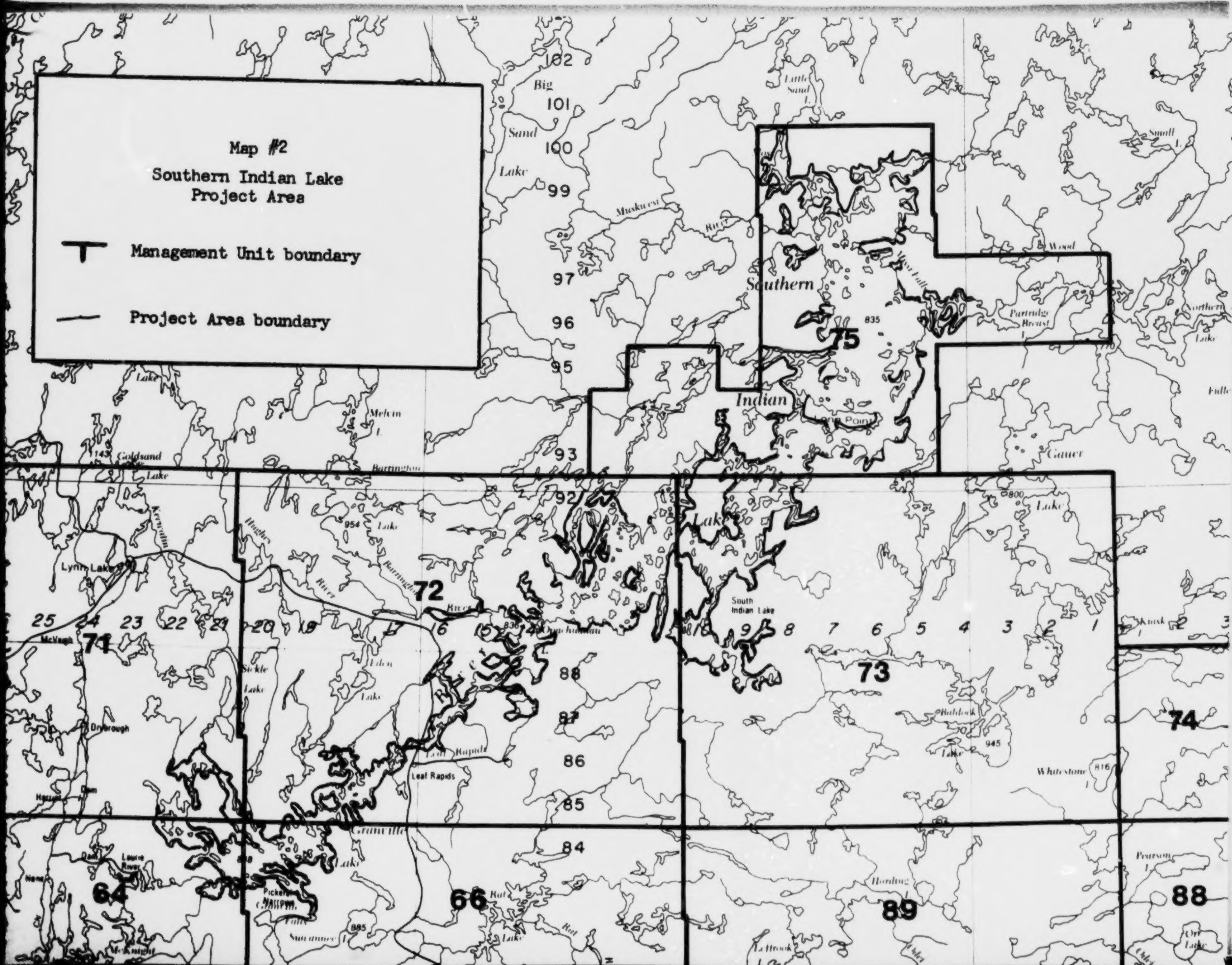
SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.


HUDSON BAY
LAKE WINNIPEG
LAKE MANITOBA

Map #1

SOUTH INDIAN LAKE PROJECT



Map #2

Southern Indian Lake
Project Area

Management Unit boundary
Project Area boundary
Southern
Indian
Lake
South Indian Lake
Big Sand Lake
Little Sand L.
Muskwest River
Wood
Partridge Breast L.
Northern Lake
Gauer
Melvin L.
Barrington
Barrington River
Goldsand Lake
Kewatin
Lynn Lake
McVeigh
Hughes River
Sickle Lake
Eden Lake
Churchill River
Leaf Rapids
Granville Lake
Pickerel Narrows
Laurie River
McKnight
Dryborough
Harriot
Suwannee L.
Rat Lake
Rat
Harding
Lattrook L.
Baldock Lake
Whitestone L.
Pearson L.
Orr Lake
Kusk L.
Lake
Long Point
835
836
800
816
945
954
885
143
64
66
71
72
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ABSTRACT

The study of the Southern Indian Lake Project Area was conducted mainly to evaluate the effect of flooding on the forest resource in the area. Area of land and volume of merchantable timber lost and the subsequent influence on total potential annual allowable cut in the Project Area are the most important aspects of the study. Descriptions of the resource are also deemed important.

It was observed in the field, that a great variation in tree growth exists in the Project Area. In the southern zones, growth is quite good, while further north, in the Transition Zone, rate of growth decreases so much that merchantable trees are produced only where microclimate and drainage is favourable. As such, the majority of loss of merchantable area and allowable cut occurs in the southern sections of the Project Area. In the northern parts, mainly treed muskeg, a non-productive and unimportant forest type will be eliminated.

It is then concluded that a large area of productive forest land will be lost through the proposed flooding. However, because climate severely limits growth over a great deal of the Project Area, volume eliminated is relatively low and the allowable cut to be deleted quite insignificant.

Although large-scale clearing of inundated timber would be economically unjustifiable, clearing is recommended in such a manner as to utilize as much mature volume as possible, to minimize environmental degradation within the lake system and to minimize hazards of the flooded trees on the people who must use the water system after flooding.

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The Southern Indian Lake Project Area

Summary Section

I. Recommendations

Clearing and removal of affected tree vegetation should be attempted. Approximately 73,000 cunits of mature timber will be lost in the proposed flooding. This volume should be cleared and the products derived be sold wherever possible.

The clearing plan should include certain points to be effective. Clearing should take place to minimize inconveniences placed on people using the lake from the hazards of flooded timber. Areas of high incidence of water transport and activity should be made clear of all obstructions. For emergency situations, corridors cut at regular intervals to the shoreline in flooded areas are necessary.

Minimizing environmental degradation of the lake system should also be high priority in any clearing plan. Erosion of river banks and shore lines causing siltation of the lake system could possibly occur if proper procedures are not followed.

II. Objectives

The objectives of the study conducted by the Forest Inventory Section on the forest resource within the Southern Indian Lake Project Area are as follows:

1) To analyze tree characteristics which determine volume and to study the composition of the forest resource to obtain an accurate evaluation of the type of resource present in the Project Area.

2) To determine the area of land and the amount of volume to be lost through the proposed flooding and the effect which this loss will have on the total potential allowable cut of the area.

3) To assess the implications of the inundation on the forest resource in the Project Area and to make recommendations according to conclusions derived from the study.

III. Terms of Reference

The terms of reference as outlined in the study proposal are based on the assumption that all timber stands below the highwater contour (850') will be lost. The forest inventory data produced in the study will give the following:

1) Total area to be affected by flooding
2) Area classification with respect to forest productivity
3) Merchantable volume of all species
4) Merchantable volume of softwood species
5) Merchantable volume of operable softwood stands
6) Examination of beneficial effects
7) Examination of detrimental effects

IV. The Study Area: The Southern Indian Lake Project Area

The Southern Indian Lake Project Area includes all land immediately bounding the following lake system: Granville Lake, Opachuanau Lake and Southern Indian Lake up to Missi Rapids and includes South Bay and sections of the Churchill River connecting these lakes.

The entire Project Area is divided into three different sections according to Forest Region, Status of Land and Volume Table Area (or Forest Management Unit). Detailed calculations on the influence of flooding on the forest resource are based on this breakdown for a more accurate assessment.

Two Forest Regions, as delineated by Rowe (2), are included in the Project Area, the Northern Coniferous Forest Zone in the south, and the Northwestern Transition Zone in the north. The boundary line between the zones occurs approximately at Long Point on Southern Indian Lake. Distinguising factors between zones depends mainly on macro-features of vegetation.

The Forest Regions are further broken down by Status of Land. The Proposed Permanent Forest Zone and the Churchill Forest Industries Specified Area are both included in the Project Area.

Three Stand-Stock Volume Table areas have been established, one for the Specified Area and one each for the two Forest Regions of the Proposed Permanent Forest Zones. The Volume Table areas are a grouping of Forest Management Units in which tree characteristics are similar.

A summary of potential flooding by section is as follows:

Southern Indian Lake Project Area

Summary by Area of Land to be Flooded by Section

Section	Area to be Flooded		
	Acres	Square Miles	%
Churchill Forest Industries Specified Area Northern Coniferous Forest Zone - Forest Management Units 64 & 66	6,945	10.9	5.1
Proposed Permanent Forest Zone Northern Coniferous Forest Zone - Forest Management Units 71, 72 & 73	67,679	105.7	49.9
Proposed Permanent Forest Zone Northwestern Transition Zone - Forest Management Unit 75	60,910	95.2	45.0
Entire Project Area (to be flooded)	135,534	211.8	100.0

V. Methodology

The Forest Resource Inventory of the Project Area was conducted over a two-year period beginning in 1970 with the major portion completed in the summer of 1971.

Aerial photographs of the area were taken in 1969 and 1970. Forest stands were first marked and delineated on the photos. Township base maps were then produced with the information from the photos transferred to the maps. Stands on the photographs were photointerpreted according to productivity.

The field survey consisted of a variable plot size, wedged-prism cruise. Plots were cruised randomly in representative stands of the different type aggregates along the lake and river system. Approximately 5,000 plots were established in the Project Area.

The three different Stand-Stock Volume Tables constructed for the Project Area according to zone, were applied to the area of each type aggregate in the zones to give expanded volume for the type. Area and volume summaries were then produced.

To determine area and volume to be flooded, the 850' contour level was transferred onto Forest Inventory township base maps. Land area affected was planimetered and volumes to be lost were determined by applying the appropriate Volume Table to the area of each type.

VI. Observations

Within the Project Area two distinct Forest Regions are delineated by Rowe (2): the Northern Coniferous Forest Zone and the Northwestern Transition Zone.

1. Northern Coniferous Forest Zone

In this zone, climatic conditions allow reasonable tree growth and development of closed forests wherever depth of soil is adequate. However, as this particular part of the Project Area is located in the northern section of the Northern Coniferous Zone, climate does become a limiting factor in tree growth. The combinations of favorable factors which can produce excellent growth occur so very rarely that few high volume stands are found throughout the area.

The Northern Coniferous Forest Zone is characterized by a continuous forest of conifers with black spruce as the predominant species. Jack pine, white spruce, white birch, trembling aspen and balsam poplar form a minor component of the forest.

2. Northwestern Transition Zone

The Transition Zone can be separated from the Northern Coniferous Forest Zone by a number of criteria; namely, a lower density of forest vegetation decreasing along a line running from southwest to northeast, lower temperatures, shortened growing season and an increase of the extent of permanently frozen ground (1).

Climate is such a limiting factor to growth that local microclimate along with the presence or absence of drainage is critical in determining growth.

The vegetation of the Transition Zone transforms from closed stands in the Coniferous Zone to open park-like stands which is described by Rowe (2) as subarctic woodlands. However, this portion of the Project Area is found in the most southerly region of the Transition Zone and hence, does contain a very minimal number of merchantable trees, i.e. 3.6"+ D.b.h. Most merchantable trees in this zone occur in a fringe approximately 100' wide along the shoreline of the lake and around islands where the moderating effect of the lake prolongs the very short growing seasons and where drainage is better.

In Management Unit 75 productive forest land accounts for only 35% of the total land area. Only one working group is of any prominence, Black Spruce Site I; however, the Jack Pine and Hardwood Working Groups are represented.

A summary of flooded area by productivity and zone is as follows:

Southern Indian Lake Project Area
Summary of Land to be Flooded by Productivity and Zone
(in Acres)

Type	Northern Coniferous Forest Zone		Northwestern Transition Zone	Total	%
	CFI (Specified Area) M.U.s 64 & 66	Proposed Permanent Forest M.U.s 71, 72 & 73	Proposed Permanent Forest M.U. 75		
Productive Forest	3,055	52,655	24,091	79,801	58.9
Forested Non-Productive	914	12,160	28,008	42,082	31.0
Non-Forested	2,976	1,864	8,811	12,651	10.1
Total Land Flooded	6,945	67,679	60,910	135,534	100.0
Square Miles	10.9	105.7	95.2	211.8	--
% by Zone	5.1	49.9	45.0	100.0	--

VII. Conclusions

A great variation in tree growth and tree characteristics is found within the Project Area. Growth is fairly good in the southern sections, but becomes much poorer in the more northerly areas. Climate of the area is the greatest limiting factor causing this variation. This is the main reason for treed-muskeg, a non-productive forest type, occupying a majority of the land area in the Transition Zone.

A total of 135,534 acres or 211.8 square miles will be lost through the proposed flooding project. Only 5.1 percent of this area is presently committed to a wood-utilizing company.

Of the total area to be flooded, 60% is classed as productive forest land with the remaining either non-productive forest land or non-forest land.

The only working group which will be affected at all by flooding is Black Spruce Site I, and in any zone, not more than 9% of the area within this working group will be lost.

Because growth is generally poor in the Project Area, a low amount of volume will be lost relative to the area of productive forest. Almost all volume lost occurs in the small diameter range.

Based on Net Operable Volume throughout the entire Project Area, any forest operation would be marginal at best.

The effect of flooding on total potential annual allowable cut must be considered as insignificant. Only the allowable cut of the Black Spruce Site I Working Group is affected, and the annual cut is almost entirely composed of small diameter black spruce trees. Only 10% of the annually available volume and area lost is presently committed.

Therefore, productive area lost will be high, but because of poor growth in the area, volume lost will be relatively low. The Project Area must be considered as more valuable for uses other than commercial timber production at this time.

The Southern Indian Lake Project Area

Comprehensive Report

I. Recommendations

In view of the implications of the proposed flooding on the forest resource within the Southern Indian Lake Project Area, it is recommended that clearing and removal of affected tree vegetation take place, and in such a manner as to utilize the presently available forest resource for timber production, to minimize inconveniences placed on people using the lake from the hazards of flooded trees along the lake shoreline, and to minimize environmental degradation of the lake and surrounding land.

The 73,000 cunits of mature merchantable volume which will be flooded have potential commercial value. As much as possible of this mature timber should be cleared, and wherever possible, the products derived be sold. Removal of the mature volume should be high priority on land presently committed to Churchill Forest Industries Company Ltd.

In order to minimize hazards placed on people using the lake from flooded timber, the following points are recommended. All trees flooded, irrespective of age, should be cleared well along the shoreline from any place of commercial or domestic activity so that no interference of activity is experienced. In areas which will not be cleared, corridors to the shoreline should be cut at strategic intervals in case emergency situations make it imperative to reach shore. All cleared areas should be made free of large floating debris which could obstruct water transport.

Vast areas of treed-muskeg will protrude through the lake surface after flooding and greatly interfere with water travel. This problem could be eliminated by crushing the stagnated trees where the incidence of travel is likely to be high.

Minimizing environmental degradation caused by flooding through judicious removal of tree cover should be high priority in any clearing plan. As a good portion of the river banks and islands are composed of clay, removal of tree cover could cause excessive erosion and siltation within the lake system. This can be retarted by leaving even mature trees where incidence of erosion is potentially high.

II. Objectives

The objectives of the study conducted by the Forest Inventory Section on the forest resource within the Southern Indian Lake Project Area are as follows:

1) To analyze tree characteristics which determine volume. To study the composition of the forest resource to obtain an accurate evaluation of the type of resource present in the Project Area.
2) To determine the area of land and the amount of volume to be lost through the proposed flooding and the effect which this loss will inflict on the total potential allowable cut of the area.
3) To assess the implications of the inundation on the forest resource in the Project Area and to make recommendations according to conclusions derived from the study.

III. Terms of Reference

In conducting this study of the forest resource of the Southern Indian Lake Project Area, it was established that certain information concerning the resource was required and that this information must be summarized in a particular form to be effective.

To assess the tree characteristics determining volume and to study the composition of the forest resource, the forest must be analyzed and described in detail. The different forest types are determined and the sites on which these forest types are found are described with respect to physiography and productivity of the species on this site type. The actual tree characteristics determining volume are analyzed with regards to total height and diameter at breast height. Age of the forest types is particularly important to establish merchantability of the type and subsequently, the age distribution of the forest in the entire Project Area.

Two broad aspects of area to be flooded are examined. These include the Status and Ownership and the productivity classification of the land. Ownership in this Project Area includes only Provincial Crown Land. However, within Provincial Crown Land, two different Status of Land occur which are the Proposed Permanent Forest Zone and the Churchill Forest Industries Specified Area.

Productivity of the land to be flooded is subdivided on the basis of Status and Ownership of the land. Productivity includes, basically, two divisions: Productive forest land and Non-Productive land.

Two types of productive land are recognized: potentially productive forest land and productive forest land. Potentially productive land includes land on which there is a potential to produce a merchantable stand of trees, such as burn and clearcut areas and is classified by expected species cover and by site. Productive types are described by species cover grouping, by age (cutting class), by site and by density.

Non-productive types include forested non-productive land and non-forested land.

Volume estimates will be provided for all productive stands to be flooded presently with Merchantable Volume and will be classified by Ownership and Status. Three different classes of volume are recognized:

Gross Merchantable Volume, Net Merchantable Volume and Net Operable Volume. The different volumes are summarized according to working groups (except in Gross Volume), species, diameter class and age class (Cutting Classes 3, 4 and 5).

Two different methods of annual allowable cut calculations are used to determine annual loss of volume and area of mature and merchantable trees through flooding. Theoretical Annual Allowable Cut is based on volume and area of all species found in stands ready to be harvested. Practical Annual Allowable Cut calculations impose operational feasibility constraints in the form of a minimum volume per acre for individual stands. Allowable cut to be lost is presented by working group, species and diameter class.

IV. STUDY AREA: The Southern Indian Lake Project Area

The Southern Indian Lake Project Area includes all land immediately bounding the following lake system: Granville Lake, Opachuanau Lake and Southern Indian Lake up to Missi Rapids and includes South Bay and the sections of the Churchill River connecting these lakes. All land in the Project Area is Provincial Crown Land.

The entire Project Area is divided into three different sections according to Forest Region, Status of Land and Volume Table Area (or Forest Management Units). Detailed calculations of the influence of flooding on the forest resource within the Project Area will be based on this breakdown for a more accurate assessment.

The Project Area includes two Forest Regions, the Northern Coniferous Forest Zone in the southern section of the Project Area, and the Northwestern Transition Zone in the north. The boundary line between the two

Regions runs from the northwest to the southeast through Long Point on Southern Indian Lake or approximately where the 57° north parallel of latitude crosses the lake. The major criteria for establishing the different zones, largely depends on macro-features of vegetation; the distribution of species and the communities in which they are associated (1). This, in turn, is basically limited or determined by the severe climate within the Project Area.

Within Forest Regions, a further breakdown occurs by Status of Land. In the Northern Coniferous Forest Zone, the proposed flooding will affect two different Status of Land, the Churchill Forest Industries Specified Area and the Proposed Permanent Forest Zone.

The Churchill Forest Industries (Manitoba) Company Ltd. (C.F.I.) obtained Forest Management Units 64 and 66 as part of their Specified Area or timber limits. However, the proposed flooding within the Southern Indian Lake Project Area will affect only a relatively small area within the Specified Area. A separate Stand-Stock Volume Table has been applied to the Specified Area, as the tree characteristics affecting volume were noted to be significantly different to those in the Proposed Permanent Forest Zone to the north of this section.

The Proposed Permanent Forest Zone differs from the Specified Area in that this land has not been allocated to a wood-utilizing organization as part of its timber limits. In the Northern Coniferous Forest section of the Project Area the Proposed Permanent Forest Zone includes sections of three Forest Management Units: 71, 72 and 73. One separate Stand-Stock Volume Table applies to this section.

In the Northwestern Transition Zone only one Status of Land is found, the Proposed Permanent Forest Zone. Only one Forest Management Unit is included in this portion of the Project Area, i.e. Forest Management Unit 75. Again, because tree characteristics affecting volume are different from the other areas, a separate Stand-Stock Volume Table is applied to this area.

V. Methodology

In order to obtain information on the Southern Indian Lake Project Area, the Forest Resource Inventory was conducted over a two-year period beginning in 1970. Inventory of the Specified Area portion of the Project Area was completed in the summer of 1970, while the inventory of the Southern Indian Lake area proper was accomplished entirely in the summer of 1971.

Aerial photography of the Specified Area was taken in 1969 at a scale of 1"=1320 feet. Southern Indian Lake photography, taken in 1970, is available only at the scale of 1"=2640 feet. Section corners and typing of forest stands were marked and delineated on these aerial photographs. The typing is based on species, site, cutting class (merchantability) and crown closure (density). Base maps were prepared at a scale equal to that of the photography of the area and township grids were produced from these base maps. Information was transferred from the typed photographs onto these base maps. The stands, typed on the photographs, were photointerpreted and numbered according to productivity. Photo mosaics of the Project Area, at a 50% reduction in scale, were also constructed.

The field survey consisted of a variable plot size, wedged-prism timber cruise. Representative stands of different type-aggregates, in which plots were randomly located, were sampled along the lake and river system. Number of plots in each type-aggregate was gauged according to the frequency of the particular type in the area. In total, approximagely 5,000 plots were cruised through the entire project area.

Three different Stand-Stock Volume Tables were constructed for the different zones because of the variation in growth throughout the Project Area. Areas for all stands and types delineated were determined. The volumes for merchantable stands were applied according to their listed type-aggregate code from the Stand-Stock Volume Table giving expanded volume for each type aggregate according to zone for Gross Merchantable, Net Merchantable and Net Operable Volumes. Expanded Volume summaries and summaries of areas are the next-to-final step in the system. Forest Inventory Reports for the management unit in which both area and volume are summarized to calculate annual allowable cuts have been written.

To determine area of land in the Project Area to be flooded, the 850'contour level was transferred by Manitoba Hydro onto the Forest Inventory township base maps. All land to be lost in the proposed flooding was planimetered, and recorded and compiled by computer. Volumes lost were determined by applying the appropriate Stand-Stock Volume Table to the total area of each type aggregate. Computer reports of area and volume summaries were then constructed.

This report, is then, the summary of all information gathered and work completed for the Southern Indian Lake Project Area.

1. Rotation Period

Rotation periods used for the Forest Management Units within which the Project Area falls were determined on the basis of present market conditions for the various species and the size and type of products for which the species are most suited. The rotation periods apply to the entire Project Area except in Black Spruce Site I.

The following rotation ages apply to the various working groups:

Jack Pine, All Sites	80 Years
Black Spruce, Site I - M.U.s 64 & 66	80 Years
Black Spruce, Site I - M.U.s 71, 72, 73 & 75	100 Years
Black Spruce, Site II	140 Years
Black Spruce, Site III	140 Years
White Spruce, All Sites	100 Years
Balsam Fir, All Sites	80 Years
Hardwood, All Sites	80 Years

For reference purposes, the following Age Distributions by Cutting Classes are provided in Table I for each working group encountered in the Project Area. This information gives the approximate age ranges in years for each cutting class of each working group.

TABLE I

Southern Indian Lake Project Area

Age Distribution by Cutting Classes and Working Groups

Working Group	Management Unit	Cutting Class				
		1	2	3	4	5
Jack Pine, All Sites	All	1-10	11-25	26-70	71-90	91+
Black Spruce, Site I	64 + 66	1-15	16-30	31-70	71-90	91+
	71, 72, 73, 75	1-15	16-35	36-80	81-120	121+
Black Spruce, Sites II & III	All	1-30	31-75	76-120	121-160	161+
White Spruce, All Sites	All	1-20	21-30	31-90	91-110	111+
Balsam Fir, All Sites	All	1-10	11-25	26-70	71-90	91+
Tamarack Larch, All Sites	All	1-25	26-70	71-120	121-160	161+
Hardwoods, All Sites)	All	1-15	16-30	31-70	71-90	91+

VI. Observations

Within the Project Area two distinct Forest Regions are delineated by Rowe (2). These include, in the southern part, the Northern Coniferous Forest, and to the north, the Northwestern Transition Zone.

1. Northern Coniferous Forest Zone

This zone comprises the southern section of the Project Area south from Long Point on Southern Indian Lake or south from approximately the 57° north parallel of latitude to the south of Granville Lake.

a) Climate

Climatic conditions allow reasonable tree growth and development of closed forests wherever depth of soil is adequate. Climate becomes a limiting factor in tree growth in this portion of the Northern Coniferous Forest Zone. Total frost-free days from a base temperature of 32.5°F only amount to 80-90 for the area. Perhaps the greatest limiting factor to growth is that there occurs only 1200-1600 degree days in the area as compared to 2700 to 2800 for the Winnipeg area.

b) Physiography

As glaciation was intense, the resulting relief is irregular with rocky parallel ridges separating poorly-drained depressions and innumerable narrow lakes and channels. In some parts of the Southern Indian Lake, islands are formed by steep, rock cliffs projecting from the water surface. Soil deposits are thin on uplands, but can be moderately deep between rock ridges forming a few relatively good forest sites. Good forest growth was observed to be growing over deposits of varved clay.

c) Forest Classification

The Northern Coniferous Forest Zone is characterized by continuous forest of conifers with black spruce as the predominant species forming stands on the thin soils of the uplands, as well as on the poorly-drained lowlands.

Other species compose only a very minor component of the forest. Jack pine, the second most prevalent species, is found mainly on upland well-drained sites. This species may be associated in stands with Hardwood and also black spruce. Where more favourable conditions of soil and local climate exist, the minor component of white birch, trembling aspen and balsam poplar form mixed stands of reasonable growth. White spruce is an extremely minor component of this area.

2. Northwestern Transition Zone

The Northwestern Transition Zone is bounded to the south by the Northern Coniferous Forest Zone and comprises the remaining northern portion of Southern Indian Lake Project Area. The boundary between the two zones marks the end of the commercial forest area. Gill (1) has suggested that the Transition Zone can be separated from the Northern Coniferous Forest Zone to the south by a number of criteria; namely, a lower percentage of forest vegetation decreasing along a line running from southwest to northeast, lower temperatures, shortened growing season and an increase of the extent of permanently frozen ground. Although the boundary between the two zones is, on the whole, generally indistinct, it is quite easy to recognize in the Southern Indian Lake area.

a) Climate

In this zone climatic conditions are more of a limiting factor to forest growth than in the Northern Coniferous Zone. The number of frost-free days decreases in this area to 70-80 from 80-90 in the southern section. Accordingly, the number of degree days decreases to 900-1200 from 1200-1600 for the southern area. Permafrost in this area becomes continuous and hence, is worthy of mention as it is probably an indicator of climate. Climate is such a critical limiting factor to growth, that local micro-climate, along with the presence or absence of drainage is critical in determining growth.

b) Physiography

This area was also under intense glaciation, but unlike the Coniferous Zone, the glaciers produced an area of generally low relief plus shallow depths of glacial till over bedrock contributing to the prevalence of water-filled depressions and vast stretches of country appearing to be almost as much lake as land. Eskers, till ridges and rock knobs are common surface forms. In contrast to the Coniferous Zone, the severe climate has almost entirely restricted podsol profile development in this area.

c) Forest Classification

The forest vegetation of the Transition Zone transforms from closed stands in the Coniferous Zone to open park-like stands. This is indicative of the varying mixture of forest and tundra vegetation which this zone supports and it is described by Rowe (2) as being open subarctic woodlands. However, these merchantable trees are confined to fringe stands approximately 100 feet in depth along shorelines and around islands on Southern Indian Lake where well-drained sites occur and the growing season may be prolonged by the moderating effect of the lake. Level areas back from the shore lines support the spaghnum moss of the muskeg or the mixed vegetation of moss and scattered, stagnated spruce which can be 100+ years in age.

In this portion of the Transition Zone productive forest land accounts for only 35% of the entire northern portion of the Project Area. Only one prominant working group is found in the area, i.e. black spruce. However, the Jack Pine and Hardwoods Working Group are represented.

Tables II, III, and IV are presented to summarize the characteristics of the various forest working groups encountered in the Project Area by zone.

TABLE II

Characteristics of Working Groups

Found in the Southern Indian Lake Project Area

Churchill Forest Industries Specified Area - M.U.s 64 & 66

Working Group	Site	Primary Species	Associate Species	Rotation in Years	D.b.h. Range at Rotation	Height Range at Rotation	Gross Merchantable Volume Range at Rotation (All Species)	Landform	Soil Moisture	Drainage
Jack Pine	I	Jack Pine	Black Spruce Trembling Aspen White Birch	80	6"-13"	50'-65'	13 - 21 cunits per acre	Slopes, Intermediate terraces and small rock outcrops	Fresh to moist	Good
Jack Pine	II	Jack Pine	Black Spruce Trembling Aspen	80	4"-10"	25'-40'	8 - 13 cunits per acre	Rock Outcrops, higher gravel beach ridges and outwash and moraine ridges	Dry to arid	Excessive
Black Spruce	I	Black Spruce	Jack Pine White Spruce Balsam Fir Trembling Aspen	80	5"-12"	40'-55'	10 - 19 cunits per acre	Low glacial till ridges and lacustrine flats	Moist to wet	Good
Black Spruce	II	Black Spruce	Tamarack Larch White Birch	140	4"-9"	30'-45'	4 - 10 cunits per acre	Flat, deep organic terrain	Wet to saturated	Insufficient
Black Spruce	III	Black Spruce	Jack Pine Trembling Aspen White Birch	140	4"-11"	35'-50'	7 - 12 cunits per acre	Associated with rock outcrops	Fresh to dry	Excessive
White Spruce	I		Black Spruce Trembling Aspen Balsam Fir	100	9"-21"	50'-75'	25 - 38 cunits per acre	Lacustrine flats immediately adjacent to rivers and lake	Moist to fresh	Good
Balsam Fir	I	Balsam Fir	Black Spruce White Spruce Trembling Aspen White Birch	80	5"-12"	35'-50'	15 - 19 cunits per acre	Lacustrine flats immediately adjacent to rivers and lakes	Moist to fresh	Good
Hardwood	I	Trembling Aspen Balsam Poplar White Birch	Jack Pine Black Spruce White Spruce Balsam Fir	80	6"-16"	50'-70'	13-22 cunits per acre	Slopes and intermediate terraces, lacustrine flats	Fresh to very moist	Good

TABLE III

Characteristics of Working Groups Found
in the Southern Indian Lake Project Area
Northern Coniferous Zone - Proposed Permanent Forest Zone - M.U.s 71, 72 & 73

Working Group	Site	Primary Species	Associate Species	Rotation in Years	D.b.h. Range at Rotation	Height Range at Rotation	Gross Merchantable Volume Range at Rotation (All Species)	Landform	Soil Moisture	Drainage
Jack Pine	I	Jack Pine	Black Spruce Trembling Aspen White Birch	80	6"-12"	35'-50'	6 - 8 cunits per acre	Slopes, Intermediate terraces and small rock outcrops	Fresh to moist	Good
Jack Pine	II	Jack Pine	Black Spruce Trembling Aspen White Birch	80	5"-9"	30'-40'	5 - 7 cunits per acre	Rock outcrops, higher gravel beach ridges and outwash and moraine ridges	Dry to arid	Excessive
Black Spruce	I	Black Spruce	Jack Pine Balsam Fir Trembling Aspen White Spruce	100	5"-10"	35'-50'	6 - 14 cunits per acre	Low glacial till ridges and lacustrine flats	Moist to wet	Good
Black Spruce	II	Black Spruce	Tamarack Larch Balsam Poplar	140	NO STANDS	AT	ROTATION	Flat, deep organic terrain	Wet to saturated	Insufficien
Black Spruce	III	Black Spruce	Jack Pine Trembling Aspen	140	NO STANDS	AT	ROTATION	Associated with rock outcrops	Fresh to dry	Excessive
White Spruce	I	White Spruce	Black Spruce Trembling Aspen	100	7"-14"	40'-60'	12 - 17 cunits per acre	Lacustrine flats immediately adjacent to rivers and lakes	Moist to fresh	Good
Hardwood	I	Trembling Aspen Balsam Poplar White Birch	Black Spruce Jack Pine White Spruce	80	5"-10"	35'-50'	6 - 13 Cunits per acre	Slopes and intermediate terraces, lacustrine flats	Fresh to very moist	Good

TABLE IV

Characteristics of Working Groups Found in the Southern Indian Lake Project Area

Northwestern Transition Zone - Proposed Permanent Forest Zone - Management Unit 75

Working Group	Site	Primary Species	Associate Species	Rotation in Years	D.b.h. Range at Rotation	Height Range at Rotation	Gross Merchantable Volume Range at Rotation (All Species)	Landform	Soil Moisture	Drainage
Jack Pine	I	Jack Pine	Black Spruce White Birch	80	4"-7"	25'-40'	3 - 6 cunits per acre	Slopes, Intermediate terraces and small rock outcrops	Fresh to moist	Good
Jack Pine	II	Jack Pine	Black Spruce White Birch	80	NO	STANDS	AT ROTATION	Rock outcrops, higher gravel beach ridges and outwash and moraine ridges	Dry to arid	Excessive
Black Spruce	I	Black Spruce	Jack Pine White Birch	100	4"-8"	25'-45'	3 - 6 cunits per acre	Low glacial till ridges and lacustrine flats	Moist to wet	Good
Black Spruce	II	Black Spruce	Tamarack Larch Balsam Poplar	140	NO	STANDS	AT ROTATION	Flat, deep organic terrain	Wet to saturated	Insufficient
Hardwood	I	Trembling Aspen Balsam Poplar White Birch	Black Spruce Jack Pine	80	NO	STANDS	AT ROTATION	Slopes and intermediate terraces, lacustrine flats	Fresh to very moist	Good

3. Area to be Lost by Flooding

Total area to be lost by the proposed flooding to the 850' contour is 135,534 acres or 211.8 square miles.

This area is further subdivided into three sections according to Forest Region, Status of Land, and Volume Table Area (or Forest Management unit). A more detailed explanation of the zones is given in section IV. All land to be flooded in the Project Area is owned by the Provincial Crown. A summary of potential flooding by section is as follows:

Southern Indian Lake Project Area
Summary by Area of Land to be Flooded by Section

Section	Area to be Flooded		
	Acres	Square Miles	%
Churchill Forest Industries Specified Area Northern Coniferous Forest Zone - Forest Management Units 64 & 66	6,495	10.9	5.1
Proposed Permanent Forest Zone Northern Coniferous Forest Zone - Forest Management Units 71, 72 & 73	67,679	105.7	49.9
Proposed Permanent Forest Zone Northwestern Transition Zone - Forest Management Unit 75	60,910	95.2	45.0
Entire Project Area	135,534	211.8	100.0

It can be noted that land presently allocated to a timber utilizing company comprises a small proportion of the area to be flooded. The great majority of land flooded occurs in zones which are not presently being utilized by any formal organization.

Further summaries of area to be flooded are presented in "Area of Land to be Flooded by Productivity and Status" and "Area of Land to be Flooded by Township and Status", Tables V and VI respectively.

TABLE V

-Southern Indian Lake Project Area-

Area of Flooded Land by Township and Status

(in Acres)

Township	Churchill Forest Industries Specified Area Provincial Crown		Proposed Permanent Forest Zones Provincial Crown Land				Total Area Flooded (Acres)
Management Unit	64	66	71	72	73	75	
83-21 WPM	1,113						1,113
83-22	293						293
84-21 WPM	782						782
84-22	902						902
84-23	307						307
83-19 WPM		609					609
83-20		406					406
84-18 WPM		147					147
84-19		1,122					1,122
84-20		1,264					1,264
85-21 WPM			593				593
85-22			1,256				1,256
86-21 WPM			870				870
86-22			592				592
85-17 WPM				27			27
85-18				2,071			2,071
85-19				2,100			2,100
85-20				162			162
86-16 WPM				412			412
86-17				1,433			1,433
86-18				3,037			3,037
86-19				1,923			1,923
87-14 WPM				714			714
87-15				756			756
87-16				2,031			2,031
87-17				771			771
87-18				206			206
88-13 WPM				53			53
88-14				2,350			2,350
88-15				1,790			1,790
88-16				1,608			1,608
89-11 WPM				1,394			1,394
89-12				1,070			1,070
89-13				662			662
89-14				2,192			2,192
89-15				896			896
90-11 WPM				2,235			2,235
90-12				1,447			1,447
90-13				2,055			2,055
90-14				1,864			1,864
90-15				288			288
91-11 WPM				2,023			2,023
91-12				2,114			2,114
91-13				2,117			2,117
92-11 WPM				1,492			1,492
92-12				2,087			2,087
92-13				582			582
88- 9 WPM					1,396		1,396
88-10					474		474
89- 9 WPM					865		865
89-10					2,062		2,062

TABLE V (Cont'd)

Township	64	66	71	72	73	75	Total
90- 9 WPM					1,263		1,263
90-10					1,665		1,665
91- 8 WPM					709		709
91- 9					2,336		2,336
91-10					1,723		1,723
92- 8 WPM					2,409		2,409
92- 9					2,563		2,563
92-10					941		941
93- 5 WPM						170	170
93- 6						1,172	1,172
93- 7						1,298	1,298
93- 8						1,462	1,462
93- 9						2,534	2,534
93-10						1,502	1,502
93-11						971	971
93-12						905	905
94- 5 WPM						1,523	1,523
94- 6						1,841	1,841
94- 7						1,918	1,918
94- 8						2,008	2,008
94- 9						72	72
94-10						714	714
94-11						2,585	2,585
94-12						493	493
95- 5 WPM						1,956	1,956
95- 6						1,207	1,207
95- 7						1,996	1,996
95- 8						2,758	2,758
95-10						27	27
95-11						96	96
96- 5 WPM						1,399	1,399
96- 6						270	270
96- 7						2,804	2,804
96- 8						786	786
97- 5 WPM						1,429	1,429
97- 6						689	689
97- 7						1,558	1,558
97- 8						678	678
98- 5 WPM						454	454
98- 6						832	832
98- 7						1,875	1,875
98- 8						1,046	1,046
99- 5 WPM						1,736	1,736
99- 6						2,823	2,823
99- 7						5,961	5,961
99- 8						3,852	3,852
100- 5 WPM						1,382	1,382
100- 6						356	356
100- 7						60	60
100- 8						1,712	1,712
Total by Management Unit	3,397	3,548	3,311	45,962	18,406	60,910	135,534
Total by Volume Table Area	6,945		67,679			60,910	135,534

TABLE VI

-Southern Indian Lake Project Area-

Area of Flooded Land by Productivity and Status

(in Acres)

Type (Working Group)	Churchill Forest Industries Specified Area (M.U.s 64 & 66) Provincial Crown	Proposed Permanent Forest Zone		Total Area Flooded in Project Area	% of Productive Land Flooded	% of Total Land Flooded
		Provincial Crown (M.U.s 71, 72 & 73)	Provincial Crown (M.U. 75)			
Jack Pine, All Sites Black Spruce, Site I Black Spruce, Sites II & III White Spruce, All Sites	121 2,217 16 17	3,163 40,435 92 47	89 21,823 -- --	3,373 64,475 108 64	4.2 80.8 0.1 0.1	
Total Softwood	2,371	43,737	21,912	68,020	85.2	50.2
Total Hardwood	562	5,628	976	7,166	9.0	5.3
Total Forested Productive	2,933	49,365	22,888	75,186	94.2	55.5
c.c.o. Jack Pine, All Sites c.c.o. Black Spruce, Site I c.c.o. Black Spruce, Sites II & III	3 118 1	859 2,429 2	73 1,130 --	935 3,677 3	1.2 4.6 --	
Total Potential Productive	122	3,290	1,203	4,615	5.8	3.4
Total Productive Land	3,055	52,655	24,091	79,801	100.0	58.9

TABLE VI (Cont'd)

Type (Working Group)	Churchill Forest Industries Specified Area (M.U.s 64 & 66) Provincial Crown	Proposed Permanent Forest Zone		Total Area Flooded in Project Area	% of Productive Land Flooded	% of Total Land Flooded
		Provincial Crown (M.U.s 71, 72 & 73)	Provincial Crown (M.U. 75)			
Treed Muskeg (700)	202	10,318	26,232	36,752		
Treed Rock (710)	48	37	10	95		
Willow/Alder (720)	389	26	527	942		
Protection Forest (730)	275	2,779	1,239	4,293		
Total Forested Non-Productive	914	13,160	28,008	42,082	--	31.0
Barren Rock (800)	9	--	--	9		
Marsh-Muskeg (830)	722	1,834	7,906	10,462		
Unclassified (840)	2,245	30	905	3,180		
Total Non-Forested Area	2,976	1,864	8,811	12,651	--	10.1
Total Land Flooded (Acres)	6,945	67,679	60,910	135,534	--	100.0
Square Miles	10.9	105.7	95.2	211.8	--	--
% by Area	5.1	49.9	45.0	100.0	--	--

4. Productive Forest Area to be Lost

The productive forest area to be lost due to flooding to the 850 foot contour is presented in Tables VII, VIII and IX. In the tables productive area describes the total productive area to be lost from cutting class 0 (potentially productive) to cutting class 5 (overmature). Net Operable Area refers to productive area in cutting classes 4 and 5 having a minimum net merchantable volume of 8 cunits per acre of jack pine, black spruce and balsam fir together, 5 inches and over in diameter (D.b.h.). Net Operable Area, therefore, is the best of the mature and overmature (cutting classes 4 and 5) portions of the productive area summary.

a) Distribution of Area by Cutting Classes for Working Groups

The following summaries of productive area distribution by cutting classes have been made only for working groups which are greatly affected in the Project Area, and in which mature and overmature volume will be eliminated by the rising water level.

In each case, the original estimates of area distribution for the management units are presented along with the estimate of areas to be flooded. From this, the remaining area of cutting classes are calculated to give the corrected estimate.

It may be noted that in each of the three sections, only the Black Spruce Site I Working Group meets the two criteria. However, in reference to the "Summary of Distribution of Flooded Area by Working Group and Cutting Class", the effect on the remaining working groups may be examined. Only in Management Units 71, 72 and 73 of the Proposed Permanent Forest Zone (Northern Coniferous Forest) is there any noticeable effect on working groups other than Black Spruce Site I. In this case, sizeable acreages of both young jack pine and hardwood stands will be flooded.

CHURCHILL FOREST INDUSTRIES SPECIFIED AREA

Management Unit 64 (Northern Coniferous Zone)

Black Spruce Site I Working Group

Rotation Age 80 Years and 5 Years Regeneration Period

Cutting Class	Original Area	Area in %	Area to be Flooded	% Flooded	Remaining Area	Area in %
0	5,658	9.5	118	5.1	5,540	9.7
1	3,120	5.2	--	--	3,120	5.4
2	25,201	42.4	659	28.2	24,542	43.0
3	22,531	37.9	1,237	53.0	21,294	37.3
4	2,938	5.0	320	13.7	2,618	4.6
5	1	--	1	--	--	--
Total	59,449	100.0	2,335	100.0	57,114	100.0

PROPOSED PERMANENT FOREST ZONE

Management Units 71, 72 & 73 (Northern Coniferous Forest Zone)

Black Spruce Site I Working Group

Rotation Age 100 Years and 5 Years Regeneration Period

Cutting Class	Original Area	Area in %	Area to be Flooded	% Flooded	Remaining Area	Area in %
0	29,237	5.2	2,429	5.7	26,808	5.2
1	13,687	2.5	928	2.2	12,759	2.5
2	307,758	55.2	17,372	40.5	290,386	56.4
3	180,491	32.4	17,444	40.7	163,047	31.7
4	22,841	4.1	3,169	7.4	19,672	3.8
5	3,612	0.6	1,522	3.5	2,090	0.4
Total	557,626	100.0	72,864	100.0	514,762	100.0

PROPOSED PERMANENT FOREST ZONE

Management Unit 75 (Northwestern Transition Zone)

Black Spruce Site I Working Group

Rotation Age 100 Years and 5 Years Regeneration Period

Cutting Class	Original Area	Area in %	Area to be Flooded	% Flooded	Remaining Area	Area in %
0	11,856	4.6	1,130	4.9	10,726	4.6
1	16,439	6.5	1,018	4.4	15,421	6.6
2	148,048	57.7	11,856	51.7	136,192	58.3
3	43,332	16.9	3,637	15.8	39,695	17.0
4	35,871	14.0	5,022	21.9	30,849	13.2
5	840	0.3	290	1.3	550	0.3
Total	256,386	100.0	22,953	100.0	233,433	100.0

TABLE VII

Summary of Distribution of Flooded Area by Working Groups and Cutting Class

In

Churchill Forest Industries Specified Area

(Northern Coniferous Zone)

(in Acres)

Working Group	Productive Area								Net Operable Area		
	Site	Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	All	3	5	95	21	--	--	124	--	--	--
Black Spruce	I	118	--	659	1,237	320	1	2,335	313	1	314
Black Spruce	II & III	1	7	6	3	--	--	17	--	--	--
White Spruce	All	--	--	--	--	17	--	17	17	--	17
Total Softwood	--	122	12	760	1,261	337	1	2,493	330	1	331
Hardwoods (All Species)	All	--	--	223	293	46	--	562	--	--	--
Total	--	122	12	983	1,554	383	1	3,055	330	1	331
% of Total		4.0	0.4	32.2	50.9	12.5	--	100.0	100.0	--	100.0

TABLE VIII

Summary of Distribution of Flooded Area by Working Groups and Cutting Class

Proposed Permanent Forest Zone

(Northern Coniferous Zone - M.U.s 71, 72 & 73)

(in Acres)

Working Group	Site	Productive Area							Net Operable Area		
		Cutting Class							4	5	Total
		0	1	2	3	4	5	Total			
Jack Pine	All	859	30	2,479	649	5	--	4,022	--	--	--
Black Spruce	I	2,429	928	17,372	17,444	3,169	1,522	42,864	2,386	992	3,378
Black Spruce	II & III	2	--	--	92	--	--	94	--	--	--
White Spruce	All	--	--	--	20	27	--	47	27	--	27
Total Softwood	--	3,290	958	19,851	18,205	3,201	1,522	47,027	2,413	992	3,405
Hardwoods (All Species)	All	--	9	4,397	1,222	--	--	5,628	--	--	--
Total	--	3,290	967	24,248	19,427	3,201	1,522	52,655	2,413	992	3,405
% of Total	--	6.2	1.8	46.1	36.9	6.1	2.9	100.0	70.9	29.1	100.0

TABLE IX

Summary of Distribution of Flooded Area by Working Groups and Cutting Class

Proposed Permanent Forest Zone

(Northwestern Transition Zone - Management Unit 75)

(in Acres)

Working Group	Productive Area								Net Operable Area		
	Site	Cutting Class									
		0	1	2	3	4	5	Total	4	5	Total
Jack Pine	All	73	--	89	--	--	--	162	--	--	--
Black Spruce	I	1,130	1,018	11,856	3,637	5,022	290	22,953	--	--	--
Total Softwood	--	1,203	1,018	11,945	3,637	5,022	290	23,115	--	--	--
Hardwoods (All Species)	All	--	--	942	34	--	--	976	--	--	--
Total	--	1,203	1,018	12,887	3,671	5,022	290	24,091	--	--	--
% of Total		5.0	4.2	53.5	15.2	20.8	1.3	100.0	--	--	--

5. Timber Volume to be Lost

Three separate Stand-Stock Volume Tables according to section were deemed necessary for the Project Area because tree characteristics influencing volume were observed to be significantly different between the three areas. Similarly, separate summaries of volume to be lost have been developed for each section. These summaries include three types of volumes: Gross Merchantable Volume, Net Merchantable Volume and Net Operable Volume.

a) Gross Merchantable Volume

Gross Merchantable Volume estimates of wood to be lost are given by zone in Table X. The Gross Merchantable Volume is the volume of all species with diameter 3.6 inches at breast height and larger, and is calculated on the basis of a 12-inch stump and the following specified top diameters:

i) Jack Pine, Black Spruce and White Spruce - top diameter 3"

ii) Balsam Fir, Tamarack Larch and Hardwood species - top diameter 4"

The Gross Merchantable Volume estimate indicates the total wood volume available in Intermediate, Mature and Overmature stands (Cutting Classes 3, 4 and 5) in the Project Area.

Statistical reports covering the wood volume in the Project Area as produced by computer analysis are presented as Appendix I.

b) Net Merchantable Volume

Net Merchantable Volume estimates of wood to be lost in the Southern Indian Lake Project Area are given in Table XI. The Net Merchantable Volume is determined by applying cull factors to cover decay, breakage and harvesting loss to be expected in the area. The following cull factors apply in the study area.

Cull Factors (%)

Southern Indian Lake Project Area

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black and White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
All Hardwoods	20%	40%

c) Net Operable Volume

Net Operable Volume is the volume of all operable stands. An operable stand is one which contains a minimum of 800 or greater cubic feet per acre in Cutting Classes 4 and 5 only of the four major Softwood Species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) excluding trees 4" D.b.h.

The total Net Operable Volume which will be lost by proposed flooding by species and zone is given in Table XII.

A total of 293,400 cunits of Gross Merchantable Volume could be lost through the proposed flooding in the Southern Indian Lake Project Area. Approximately 78% of the total loss will occur in Management Units 71, 72 and 73, with the remaining split equally between the Churchill Forest Industries Specified Area and Management Unit 75.

When the loss figures are weighted by Merchantable Productive Area within the respective zones, i.e. area of Cutting Classes 3, 4 and 5, average productivity of the different zones may be assessed. The Specified Area will lose almost an equal amount of Gross Volume to that of Management Unit 75, but this volume is contained on a much smaller area than that in Management Unit 75. Therefore, the Specified Area is much more productive (by approximately a factor of 4) than Management Unit 75. The average productivity of the Specified Area is 15.4 cunits per acre while that of Management Unit 75 is only 3.7 cunits per acre. The great majority of Gross Volume to be lost occurs in Management Units 71, 72 and 73, a zone less productive than the Specified Area. Average productivity in this zone is 9.5 cunits per acre.

Over 93% of the total Gross Merchantable Volume lost is Softwood Volume. Black Spruce volume accounts for almost 90% of the total material lost. Trembling aspen, jack pine and white birch account for most of the remaining volume.

Only 5% of the total volume is composed on 10"+ D.b.h. material, and hence, the great majority of volume lost will be in the small diameter classes.

Less than 10% cull was calculated in the Project Area since the majority species in the area is Black Spruce and occurs in the lower diameter classes.

There is very little Net Operable Volume in the Project Area as volumes per acre of the operable species are low and hence, by definition, would not qualify as operable stands. Management Units 71, 72 and 73 contain the majority of total Net Operable Volume with the remaining volume occurring in the Specified Area. No Operable Volume is found in Management Unit 75 as tree growth in this area is very poor and consequently, no operating in this management unit is justifiable from the standpoint of forest economics.

TABLE X

Southern Indian Lake Project Area

Potential Loss of Gross Merchantable Volume Through Proposed Flooding

By Zone and Diameter Class

(in Cunits)

Species	Churchill Forest Industries Specified Area, M.U.s 64 & 66			Proposed Permanent Forest Zone Management Units 71, 72 & 73			Proposed Permanent Forest Zone M.U. 75			Total Loss of Gross M. Vol. Entire Project Area		
	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total
Jack Pine	1,830	460	2,290	6,520	470	6,990	150	--	150	8,500	930	9,430
Black Spruce	18,020	1,030	19,050	197,600	8,910	206,510	32,730	320	33,050	248,350	10,260	258,610
White Spruce	1,100	810	1,910	2,050	1,150	3,200	--	--	--	3,150	1,960	5,110
Balsam Fir	100	10	110	20	10	30	--	--	--	120	20	140
Tamarack Larch	10	--	10	110	20	130	30	--	30	150	20	170
Total Softwood	21,060	2,310	23,370	206,300	10,560	216,860	32,910	320	33,230	260,270	13,190	273,460
Trembling Aspen	4,370	1,030	5,400	4,850	680	5,530	30	--	30	9,250	1,710	10,960
Balsam Poplar	400	130	530	530	130	660	--	--	--	930	260	1,190
White Birch	580	20	600	6,750	40	6,790	400	--	400	7,730	60	7,790
Total Hardwood	5,350	1,180	6,530	12,130	850	12,980	430	--	430	17,910	2,030	19,940
Total Loss	26,410	3,490	29,900	218,430	11,410	229,840	33,340	320	33,660	278,180	15,220	293,400
% by Zone	--	--	10.2	--	--	78.3	--	--	11.5	--	--	100.0

TABLE XI

Southern Indian Lake Project Area

Potential Loss of Net Merchantable Volume Through Proposed Flooding

By Zone and Diameter Class

(in Cunits)

Species	Churchill Forest Industries Specified Area, M.U.s 64 & 66			Proposed Permanent Forest Zone Management Units 71, 72 & 73			Proposed Permanent Forest Zone M.U. 75			Total Loss of Net M. Vol. Entire Project Area		
	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total
Jack Pine	1,610	380	1,990	5,790	400	6,190	140	--	140	7,540	780	8,320
Black Spruce	16,970	910	17,880	184,270	8,140	192,410	31,000	290	31,290	232,240	9,340	241,580
White Spruce	1,040	730	1,770	1,920	1,040	2,960	--	--	--	2,960	1,770	4,730
Balsam Fir	80	--	80	20	10	30	--	--	--	100	10	110
Tamarack Larch	10	--	10	80	10	90	30	--	30	120	10	130
Total Softwood	19,710	2,020	21,730	192,080	9,600	201,680	31,170	290	31,460	242,960	11,910	254,870
Trembling Aspen	3,480	600	4,080	3,900	400	4,300	20	--	20	7,400	1,000	8,400
Balsam Poplar	300	60	360	410	80	490	--	--	--	710	140	850
White Birch	460	20	480	5,310	20	5,330	330	--	330	6,100	40	6,140
Total Hardwood	4,240	680	4,920	9,620	500	10,120	350	--	350	14,210	1,180	15,390
Total Loss	23,950	2,700	26,650	201,700	10,100	211,800	31,520	290	31,810	257,170	13,090	270,260
% by Zone	--	--	9.9	--	--	78.4	--	--	11.7	--	--	100.0

TABLE XII

Southern Indian Lake Project Area

Potential Loss of Net Operable Volume Through Proposed Flooding

By Zone and Diameter Class

(in Cunits)

Species	Churchill Forest Industries Specified Area - M.U.s 64 & 66				Proposed Permanent Forest Zone M.U.s 71, 72 & 73				Proposed Permanent Forest Zone M.U. 75				Total Loss of Operable Volume Entire Project Area			
	5"	6"-9"	10"+	Total	5"	6"-9"	10"+	Total	5"	6"-9"	10"+	Total	5"	6"-9"	10"+	Total
Jack Pine	60	380	100	540	--	40	--	40	--	--	--	--	60	420	100	580
Black Spruce	900	2,280	250	3,430	10,890	20,610	1,850	33,350	--	--	--	--	11,790	22,890	2,100	36,780
White Spruce	30	170	210	410	60	610	450	1,120	--	--	--	--	90	780	660	1,530
Balsam Fir	10	30	--	40	--	--	--	--	--	--	--	--	10	30	--	40
Total Softwood Loss	1,000	2,860	560	4,420	10,950	21,260	2,300	34,510	--	--	--	--	11,950	24,120	2,860	38,930
Percent by Zone	--	--	--	11.4	--	--	--	88.6	--	--	--	--	--	--	--	100.0

6. Effect on Annual Allowable Cut

Annual Allowable Cut calculations have been made for all Forest Management Units involved in the Project Area in order to provide guidelines for species and volumes available for harvest on an annual basis as required for sustained yield (continuous wood supply) management. Both Theoretical and Practical Annual Allowable Cut have been determined. Calculations were made for each working group, and in addition, for each species.

Theoretical and Practical Annual Allowable Cut which will be lost through the proposed flooding in the Project Area have been calculated for each zone by working groups and species. For comparison purposes, the Practical Annual Allowable Cut was selected as this calculation gives a realistic volume estimate available for future disposition. In all Forest Management Units, a 12% reduction factor was applied to calculated estimates to cover losses due to fire, new construction and withdrawals from commercial harvesting operations (i.e. recreation areas). In examination of Forest Management Units, therefore, the critical level is a 12% or greater reduction in the annual allowable cut.

Comparison of allowable cut to be lost through proposed flooding to the total potential allowable cut available in Management Units 71, 72 and 73 is not practical. Present estimates of total allowable cut available represent a strip of land six miles wide along the shoreline of Southern Indian Lake, and hence, do not represent quantities available for the entire area of the management units. Estimate of total potential allowable cuts are not available for the entire units.

a) Forest Management Unit 64 - The Specified Area

Annual allowable cut lost through flooding in the Specified Area is compared with total volume available in only Management Unit 64. With flooding of the Rat River Project Area which includes Forest Management Unit 66, estimates of allowable cut remaining in Forest Management Unit 66 after flooding in the Southern Indian Lake Project Area would be misleading.

Only two working groups were affected to an extent which required examination. Black Spruce Site I losses were greatest with a total loss of 0.32% of total potential allowable cut through flooding. This figure is well within the 12% reduction factor built into the calculations.

A slight loss of Operable Area within the White Spruce Working Group occurs; however, this loss compared to total available is insignificant.

b) Forest Management Units 71, 72 and 73 - The Proposed Permanent Forest Zone

The majority of loss in Practical cut will occur in this portion of the Project Area. It accounts for approximately 90% of the total loss.

Two working groups will suffer losses: the Black Spruce Site I Working Group, and the White Spruce Working Group. Losses in the White Spruce Working Group are insignificant. A total of 1,500 cunits per year will be deducted from total potential allowable cut by the inundation in the Black Spruce Site I Working Group.

No relative comparison of loss is available as estimates of allowable cut for entire management units involved are not available.

c) Forest Management Unit 75 - The Proposed Permanent Forest Zone

According to the Forest Inventory Report for Management Unit 75, no Practical Annual Allowable Cut is possible for this unit as no stands qualify as Operable Stands. In no type aggregates does the volume per acre reach the 8 cunits per acre minimum. Therefore, no Practical Annual

Cut will be lost in this zone. Also, under normal conditions, no forest operation is feasible in this zone.

Summaries of Theoretical and Practical Annual Allowable Cut by Zone, Species and Diameter Class are given in Tables XIII and XIV.

TABLE XIII

Southern Indian Lake Project Area

Potential Loss of Theoretical Annual Allowable Cut Through Proposed Flooding

By Zone, Diameter Class and Species

(in Cunits)

Species	Churchill Forest Industries Specified Area, M.U.s 64 & 66			Proposed Permanent Forest Zone Management Units 71, 72 & 73			Proposed Permanent Forest Zone M.U. 75			Total Loss of Theoretical Annual Cut Entire Project Area		
	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total	4"-9"	10"+	Total
Jack Pine	30	10	40	10	--	10	--	--	--	40	10	50
Black Spruce	190	10	200	2,290	100	2,390	550	--	550	3,030	110	3,140
White Spruce	10	--	10	20	20	40	--	--	--	30	20	50
Total Softwood	230	20	250	2,320	120	2,440	550	--	550	3,100	140	3,240
Trembling Aspen	10	--	10	--	--	--	--	--	--	10	--	10
White Birch	--	--	--	30	--	30	--	--	--	30	--	30
Total Hardwood	10	--	10	30	--	30	--	--	--	40	--	40
Total Loss	240	20	260	2,350	120	2,470	550	--	550	3,140	140	3,280
% by Zone	--	--	7.9	--	--	75.3	--	--	16.8	--	--	100.0

TABLE XIV

Southern Indian Lake Project Area

Potential Loss of Practical Annual Allowable Cut Through Proposed Flooding

By Zone, Species and Diameter Group

(in Cunits)

Species	Churchill Forest Industries Specified Area-M.U.s 64 & 66				Proposed Permanent Forest Zone M.U. s 71, 72, & 73				Proposed Permanent Forest Zone M.U. 75				Total Loss of Practical Annual Cut Entire Project Area			
	5"	6"-9"	10"+	Total	5"	6"-9"	10"+	Total	5"	6"-9"	10"+	Total	5"	6"-9"	10"+	Total
Jack Pine	--	20	--	20	--	10	--	10	--	--	--	--	--	30	--	30
Black Spruce	40	100	10	150	480	900	80	1,460	--	--	--	--	520	1,000	90	1,610
White Spruce	--	--	10	10	--	20	10	30	--	--	--	--	--	20	20	40
Balsam Fir	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Softwood Loss	40	120	20	180	480	930	90	1,500	--	--	--	--	520	1,050	110	1,680
Percent by Zone	--	--	--	10.7	--	--	--	89.3	--	--	--	Nil	--	--	--	100.0

7. Timber Clearing

All trees within the area to be flooded will be killed. To minimize dollar losses, as much as possible of the merchantable volume to be lost should be salvaged and utilized commercially.

The Southern Indian Lake Project Area includes a very small portion of the Churchill Forest Industries (Manitoba) Limited's Specified Area. However, since only a very minor amount of Operable volume will be lost with inundation, and with the great difficulty of delivering the wood to the mill at The Pas, it is very doubtful whether clearing is economically justifiable in this section.

The remaining portion of the area to be flooded has not, as yet, been committed to any wood-utilizing organization, and hence, no major quantities of wood volume are being utilized for commercial purposes.

The small-dimension stock characteristic of this remaining portion hardly justifies removal of any of the merchantable volume. This, combined with transportation costs, should produce a very uneconomical basis for clearing. Cost of removal of all volume affected will greatly exceed all monetary benefits derived from removal and utilization of it.

Aside from economic considerations, other reasons for clearing should be considered. Removal of all inundated merchantable timber is not necessary for forestry purposes. Clearing should be carried out to minimize detrimental effects of flooding on access to critical areas of use on the lake. Critical areas would include future recreation sites, points of land where wind direction could force boat travellers to seek shelter around present settlements on the lake and high-use areas near hydro control structures.

Access to shore for safety purposes is very important on Southern Indian Lake because of its size and nature. Cleared and accessible points of land could prove very important in the safety of water travellers in times of poor weather conditions.

8. Beneficial Effects of Flooding

The main benefit on forestry derived from flooding of the Project Area will be the improvement of accessibility of the area making future forestry operations more economical. At present, the Southern Indian Lake area is very inaccessible and transportation cost of materials is extremely high.

Accessibility could be improved and transportation costs lowered by the construction of roads needed to freight materials to the South Bay channel area. Clearing operations could become more economical because of lower transportation costs. If materials will be barged to construction sites, improved access to the lake and improved landing facilities will also lower transportation costs improving the economics of clearing.

Clearing operations will provide employment and training for local people in forest harvesting operations.

The raising of the water level will benefit any industrial forest operation which may be developed in the future in this area. With flooding, channels in the Churchill River will become deeper and wider, facilitating large water transport. Rapids and swift currents presently restricting water transport may also be eliminated.

9. Detrimental Effects of Flooding

There will be a loss in productive forest land throughout the Southern Indian Lake area. But as forest productivity in the area is relatively low, the allowable cut lost is minor and well below the 12% reduction factor built into Practical Allowable Cut estimates.

Volumes and areas lost annually in the Churchill Forest Industries Specified Area form an insignificant amount compared to the total potential allowable cut in Forest Management Unit 64.

In Forest Management Unit 75 a good percentage of the merchantable trees are located in a fringe along the shoreline of Southern Indian Lake and around islands. As such, flooding will cause the loss of many of these trees to the extent that 14% of the Theoretical Allowable Cut will be eliminated.

Maximum water levels may have detrimental effects on adjacent forest cover including black spruce swamp areas. The impact of the effect is not known at this time and will be studied as a separate project.

VII. Conclusions

In examining the forest resource and in determining the effect of the proposed flooding on this resource within the Southern Indian Lake Project Area, certain conclusions may be derived.

There is a great variation in tree growth and tree characteristics within the Project Area. Therefore, the Southern Indian Lake Project Area can be divided into two distinct Forest Regions based on these macrofeatures of vegetation, which in turn is determined basically by climate. These two Regions include the Northern Coniferous Forest Zone and the Northwestern Transition Zone.

Tree growth is fairly good in the Northern Coniferous Forest Zone being located in the southern portion of the Project Area. This zone is further divided into two sub-zones because somewhat of a variation in growth occurs within it and also because of the status of land.

The Northwestern Transition Zone is characterized in most areas by very poor tree growth. Climate is such a limiting factor in growth of trees that merchantable trees are almost entirely located in fringe strips along the shoreline of Southern Indian Lake and around the edges of islands within the lake. The great majority of the forest vegetation in this zone is composed of dwarfed, stagnated black spruce trees which could be over one hundred years of age. A larger area of treed-muskeg than productive forest land will be flooded in this zone, however, this type is of no loss to timber production.

A total of 135,534 acres or 211.8 square miles are predicted to be lost through the proposed flooding project. Only 5% of the loss will occur on land which is already allocated to the Churchill Forest Industries Company Ltd. The great majority of land has not been allocated to any wood-utilizing organization.

Of the total area to be flooded, almost 60% is classed as Productive Land and is now producing merchantable trees, or has the potential for doing so. Forested Non-Productive and Non-Forested Land account for the remaining 40% of the land area to be flooded.

The only working group which will be affected at all by flooding in all zones is Black Spruce Site I. However, not more than 9% of the area within this working group in any one zone will be lost. The 9% loss will occur in Management Unit 75.

Area distribution within age classes will not change from present in any zone as the flooding will eliminate material of different age classes in the same proportion as it is now found.

Each of the three different sub-zones has its own Stand-Stock Volume Table. Values of volume per acre comprising the volume tables decrease rapidly to the north in the Project Area with volumes in the Specified Area being the highest. Those in Management Units 71, 72 and 73 are lower and in the Northwestern Transition Zone, volume per acre is very low owing to the harsh climate within this zone.

A total of 293,400 cunits of Gross Merchantable Volume will be lost with the proposed flooding. Almost all of this volume is Black Spruce and is found almost entirely in the form of small trees, i.e. 4"-9" Diameter class. Very little cull is subtracted from the Gross Volume to obtain Net Merchantable Volume because Black Spruce in this area, the majority species, is of high quality.

Total Net Operable Volume is small in proportion to Net Merchantable since volume per acre in most stands is low and hence, they do not meet the qualifications of an "Operable" stand. No Net Operable Volume is found in Management Unit 75. Therefore, no normal operating could be feasibly or justifiably undertaken in the forests of Forest Management Unit 75. In the other two zones, only a very small operation could be maintained.

In all three zones flooding will be severe enough in only one working group, Black Spruce Site I, to lower total potential annual allowable cut in the Project Area. Effect of flooding on annual cut in all other working groups is insignificant. The annual cut lost is almost entirely composed of small diameter black spruce trees. Only 10% of these volumes lost annually occurs on committed land. The actual loss of annual allowable cut, must therefore, be viewed as relatively insignificant.

Clearing operations should be attempted because of the undesirable effects of flooded trees. However, total clearing of all affected trees is economically unjustifiable. Removal operations which are conducted will most likely be uneconomical becuase of the characteristically small dimensions of the trees and the great distance to the mill at The Pas and any markets.

VIII. References

1. Gill, C. B. Forest Resources Inventory - Inaccessible Forest Zone and the uncruised portion of the Inaccessible Area of Manitoba, Report No. 9
Forest Service, Department of Mines and Natural Resources, Province of Manitoba, Winnipeg, 1960.

2. Rowe, J. S. Forest Regions of Canada, Bulletin 123, Forestry Branch, Department of Northern Affairs and Natural Resources, Ottawa, Canada, 1959.

APPENDIX I

Calculations of the Influence of Proposed Flooding on Annual Allowable Cut in the Project Area

A. Theoretical Annual Allowable Cut to be Lost Through the Proposed Flooding:

The Theoretical Annual Allowable Cut is the total amount of volume available annually using all species in calculations and taking into account no restraints on economic feasibility of harvesting the wood.

The following calculations of Theoretical Cut have been made by applying a removal period of the mature and overmature volume and associated area to be flooded. This removal period was predetermined by zone in the respective Forest Inventory Report.

Throughout the entire Project Area the total loss of Theoretical Annual Cut is 3,280 cunits over an area of 428 acres. The only working group in which a significant loss occurs is Black Spruce Site I. However, there are very minimal losses in both the White Spruce and Hardwoods Working Groups. Approximately 95% of the total loss is composed of trees 4"-9" D.b.h.

The greatest loss of Theoretical Cut occurs in Management Units 71, 72 and 73 as the greatest amount of mature volume occurs in this zone. It amounts to 2,470 cunits per annum. The deduction in Management Unit 75 is double of that in the Specified Area.

The total deduction of Theoretical Cut to be made from Management Unit 64 of the Churchill Forest Industries Specified Area is very insignificant as the 260 cunits per year lost accounts for only 0.33% of the total Theoretical Allowable Cut available in that unit in the Black Spruce Site I Working Group.

However, in Management Unit 75, the 550 cunits per year lost by the proposed flooding represents 14.0% of the total available annual cut in the entire unit. Such a difference between the two zones exists because more Productive Area is flooded in Management Unit 75 and this area occurs in a fringe along shorelines and around islands where flooding is imminent.

A comparison of Theoretical Cut in Management Units 71, 72 and 73 on this same basis is not practical. The area to which the original allowable cut estimates refer has been defined by the Forest Inventory Section as a fringe six miles wide along the Southern Indian Lake shoreline, and hence, does not represent an entire entity as the other management units. Estimates of Theoretical cut are not available for the entire area of these management units.

CHURCHILL FOREST INDUSTRIES SPECIFIED AREA

Northern Coniferous Zone - Management Unit 64

1. Jack Pine Working Group (All Sites):

It has been determined that only 21 acres of merchantable Jack Pine Working Group growing stock in the Specified Area will be eliminated by flooding. No mature volume is affected as the entire acreage consists of intermediate-aged material. In this acreage, a total of 100 cunits will be lost. No allowable cut calculations to determine depletion have been determined. Hence, annual allowable cut estimates within this working group for the entire management unit is not affected at all.

Jack Pine Working Group (All Sites)
Net Merchantable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	JP	Total
III	4"-9"	10	10
21	10"+	--	--
Acres	Total	10	10

2. Black Spruce Site I Working Group:

Twenty-Year Removal Period of the mature and overmature area and volume to be deleted because of flooding

Annual cut by area lost $\frac{321}{20}$ = 16 Acres

Annual cut by volume lost $\frac{3,990}{20}$ = 200 Cunits

Theoretical Annual Allowable Cut by Species and Size within Black Spruce Site I Working Group to be deleted from Management Unit 64 because of flooding (in Cunits)

Size	JP	BS	WS	BF	TL	TA	BA	WB	Total
4"-9"	30	190	10	--	--	10	--	--	240
10"+	10	10	--	--	--	--	--	--	20
Total	40	200	10	--	--	10	--	--	240

Percent of potential allowable cut lost by volume = $\frac{260}{79,860}$ x 100% = 0.33%

Therefore, 0.33% of the annual allowable harvest within the Black Spruce Site I Working Group will be lost due to flooding in the Churchill Forest Industries portion of the Project Area.

Adjusted Total Theoretical Annual Allowable Cut by Species and Size within Black Spruce Site I Working Group in Management Unit 64 (in Cunits)

Size	JP	BS	WS	BF	TL	TA	BA	WB	Total
4"-9"	7,350	55,490	2,580	280	50	3,320	380	1,350	70,800
10"+	1,950	3,930	2,020	50	--	680	120	50	8,800
Total	9,300	59,420	4,600	330	50	4,000	500	1,400	79,600

Black Spruce Site Working Group

Net Merchantable Volume Lost by Flooding

(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	BF	TL	TA	BA	WB	Total
III 1,237 Acres	4"-9"	96	1,294	58	4	1	84	10	22	1,569
	10"+	19	60	33	--	--	9	1	--	122
	Total	115	1,354	91	4	1	93	11	22	1,691
IV 320 Acres	4"-9"	46	374	11	1	--	17	1	6	456
	10"+	10	24	10	--	--	3	1	--	48
	Total	56	398	21	1	--	20	2	6	504
V 1 Acres	4"-9"	--	1	--	--	--	--	--	--	1
	10"+	--	--	--	--	--	--	--	--	--
	Total	--	1	--	--	--	--	--	--	1
IV & V 321 Acres	4"-9"	46	375	11	1	--	17	1	6	457
	10"+	10	24	10	--	--	3	1	--	48
	Total	56	399	21	1	--	20	2	6	505
Total 1,558 Acres		171	1,753	112	5	1	113	13	28	2,196

Black Spruce Site I Working Group

Net Merchantable Volume Remaining in M.U. 64

(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	BF	TL	TA	BA	WB	Total
III 179,918 Acres	4"-9"	25,170	163,966	7,415	468	376	13,723	1,503	3,885	216,506
	10"+	4,693	8,273	3,666	31	--	1,497	168	75	18,403
	Total	29,863	172,239	11,081	499	376	15,220	1,671	3,960	234,909
IV 98,992 Acres	4"-9"	14,504	108,710	5,086	554	101	6,576	750	2,641	138,922
	10"+	3,852	7,725	3,922	93	11	1,352	238	90	17,283
	Total	18,356	116,435	9,008	647	112	7,928	988	2,731	156,205
V 1,857 Acres	4"-9"	210	2,274	80	3	--	62	7	59	2,695
	10"+	51	142	115	2	--	11	7	2	330
	Total	261	2,416	195	5	--	73	14	61	3,025
IV & V 100,849 Acres	4"-9"	14,714	110,984	5,166	557	101	6,638	757	2,700	141,617
	10"+	3,903	7,867	4,037	95	11	1,363	245	92	17,613
	Total	18,617	118,851	9,203	652	112	8,001	1,002	2,792	159,230
Total 280,767 Acres		48,480	291,090	20,284	1,151	488	23,221	2,673	6,752	394,139

3. Black Spruce Sites II & III Working Group:

In this section of the Project Area only three acres of merchantable growing stock in this working group will be affected due to flooding. This acreage is composed of entirely intermediate-aged material; no harvestable volume is affected. Therefore, the original estimate of annual allowable harvest in Management Unit 64 in the Black Spruce Sites II & III Working Group will not change.

Black Spruce Sites II & III Working Group
Net Merchantable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	TL	TA	BA	WB	Total
III	4"-9"	--	--	--	--	--	--	--
3	10"+	--	--	--	--	--	--	--
Acres	Total	--	--	--	--	--	--	--

4. White Spruce Working Group (All Sites):

Only 17 acres of merchantable growing stock will be lost due to flooding in Management Unit 64. This volume is mature and harvestable, but is insignificant when compared to the total harvestable volume now available. No annual allowable cut estimates have been determined for White Spruce. Therefore, flooding will have negligible effect on the allowable cut in this working group for this portion of the Project Area.

White Spruce Working Group (All Sites)
Net Merchantable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	BF	TA	WB	Total
IV	4"-9"	1	7	11	3	1	1	24
17	10"+	--	1	11	--	1	1	14
Acres	Total	1	8	22	3	2	2	38

5. **Hardwoods Working Group (All Sites):**

In this working group a total of 339 acres of merchantable growing stock will be flooded in this portion of the Project Area. Of the total, 293 acres are classed as intermediate-aged, not ready for harvesting and 46 acres are classed as mature and immediately available for cutting. This amount represents only a very small proportion of the total intermediate and mature growing stock presently found in the Management Unit, and hence, there will be negligible influence on annual allowable cut in this working group.

Hardwoods Working Group (All Sites)
Net Merchantable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	TA	BA	WB	Total
III 293 Acres	4"-9"	7	16	22	203	18	16	282
	10"+	7	4	15	35	4	1	66
	Total	14	20	37	238	22	17	348
IV 46 Acres	4"-9"	1	5	2	43	1	1	53
	10"+	2	2	4	12	--	--	20
	Total	3	7	6	55	1	1	73
Total 339 Acres		17	27	43	293	23	18	421

PROPOSED PERMANENT FOREST ZONE

Northern Coniferous Zone - Management Units 71, 72 and 73

1. Jack Pine Working Group (All Sites):

A total of 654 acres of merchantable growing stock in the Jack Pine Working Group will be eliminated by the proposed flooding in this section of the Project Area. Of this, only 5 acres are mature and contain volume immediately available for harvesting. The majority of acreage is composed of intermediate-aged volume and is not ready for cutting. Therefore, the amount of mature volume affected will be insignificant and flooding will have negligible influence on the potential annual allowable harvest of the working group.

Jack Pine Working Group (All Sites)
Net Merchantable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	TL	TA	WB	Total
III 649 Acres	4"-9"	160	71	1	6	15	253
	10"+	8	12	--	--	--	20
	Total	168	83	1	6	15	273
IV 5 Acres	4"-9"	--	1	--	--	--	1
	10"+	--	--	--	--	--	--
	Total	--	1	--	--	--	1
Total 654 Acres		168	84	1	6	15	274

2. Black Spruce Site I Working Group:

Twenty-Year Removal Period of the mature and overmature area and volume to be deleted because of flooding:

Annual cut by area lost $\frac{4,691}{20}$ = 235 Acres

Annual cut by volume lost $\frac{47,790}{20}$ = 2,390 Cunits

Theoretical Annual Allowable Cut by Species and Size within Black Spruce Site I Working Group to be deleted from Management Units 71, 72 and 73 because of flooding (in Cunits).

Size	JP	BS	WS	TA	WB	Total
4"-9"	10	2,290	20	--	30	2,350
10"+	--	100	20	--	--	120
Total	10	2,390	40	--	30	2,470

Adjusted Total Theoretical Annual Allowable Cut by Species and Size within Black Spruce Site I Working Group in Management Units 71, 72 and 73 (in Cunits).

Size	JP	BS	WS	TA	WB	Total
4"-9"	80	10,440	80	60	140	10,800
10"+	10	550	60	--	--	620
Total	90	10,990	140	60	140	11,420

Black Spruce Site I Working Group

Net Merchantable Volume Lost by Flooding

(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	TL	TA	BA	WB	Total
III	4"-9"	384	13,607	96	3	88	13	353	14,544
17,444	10"+	19	552	45	--	10	4	2	632
Acres	Total	403	14,159	141	3	98	17	355	15,176
IV	4"-9"	12	3,152	43	1	13	--	42	3,263
3,169	10"+	3	170	25	--	--	--	--	198
Acres	Total	15	3,322	68	1	13	--	42	3,461
V	4"-9"	--	1,420	3	--	--	--	7	1,430
1,522	10"+	--	37	12	--	--	--	--	49
Acres	Total	--	1,457	15	--	--	--	7	1,479
IV & V	4"-9"	12	4,572	46	1	13	--	49	4,693
4,691	10"+	3	207	37	--	--	--	--	247
Acres	Total	15	4,779	83	1	13	--	49	4,940
Total 22,135 Acres		418	18,938	224	4	111	17	404	20,116

Black Spruce Site I Working Group

Net Merchantable Volume Remaining in M.U.s 71, 72 & 73

(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	TL	TA	BA	WB	Total
III	4"-9"	4,943	114,267	742	39	1,177	183	3,647	124,998
163,047	10"+	286	4,764	320	--	127	49	17	5,563
Acres	Total	5,229	119,031	1,062	39	1,304	232	3,664	130,561
IV	4"-9"	166	19,181	158	7	115	--	272	19,899
19,672	10"+	24	1,054	115	--	3	--	2	1,198
Acres	Total	190	20,235	273	7	118	--	274	21,097
V	4"-9"	--	1,705	3	1	--	--	10	1,719
2,090	10"+	--	41	12	--	--	--	--	53
Acres	Total	--	1,746	15	1	--	--	10	1,773
IV & V	4"-9"	166	20,886	161	8	115	--	282	21,618
21,762	10"+	24	1,095	127	--	3	--	2	1,251
Acres	Total	190	21,981	288	8	118	--	284	22,869
Total 184,809 Acres		5,419	141,012	1,350	47	1,422	232	3,948	153,430

3. Black Spruce Sites II & III Working Group:

In this working group no mature volume is found at all as the only merchantable growing stock consists of intermediate-aged trees. Consequently, in the Forest Inventory Report for this area, it has been recommended that no harvesting occur for a ten-year period from the present in order to allow a buildup of mature volume to sustain an annual cut. Even when this occurs, there is only sufficient area of this working group to sustain an annual cut of 12 acres. Therefore, in this working group, flooding will not affect the total potential annual allowable harvest of this section.

Black Spruce Sites II & III Working Group
Net Merchantable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	BS	Total
III	4"-9"	46	46
92	10"+	--	--
Acres	Total	46	46

4. White Spruce Working Group (All Sites):

White Spruce is the majority species in stands on only 88 acres in this portion of the Project Area. Of this, 20 acres contain intermediate-aged growing stock and the remaining 68 acres consist of mature volume immediately available for harvesting. No annual harvest has been recommended for the White Spruce Working Group as the total area is too small to manage on a sustained yield-basis.

With the flooding, the 20 acres of intermediate-aged volume and 27 acres of mature volume will be eliminated, but the total potential allowable cut for the area will not be changed.

White Spruce Working Group (All Sites)
Net Merchantable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	BS	WS	WB	Total
III	4"-9"	3	10	1	14
20	10"+	--	10	--	10
Acres	Total	3	20	1	24
IV	4"-9"	17	26	1	44
27	10"+	2	8	--	10
Acres	Total	19	34	1	54
Total 47 Acres		22	54	2	78

5. Hardwoods Working Group (All Sites):

Within the Hardwoods Working Group, it is estimated that 1,222 acres will be flooded with the raising of the water level. This entire area is composed of intermediate-aged growing stock not yet ready for harvesting. It is expected that no mature and harvestable volume will be lost.

In this portion of the Project Area only 68 acres of mature Hardwood volume were recorded. Consequently, no annual harvest has been recommended for ten years from the present until sufficient mature volume will have accumulated to sustain an annual cut. Therefore, the total annual harvest now available in the Project Area will not be decreased by flooding of growing stock within the Hardwood Working Group.

Hardwoods Working Group (All Sites)
Net Merchantable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	BF	TL	TA	BA	WB	Total
III	4"-9"	23	130	14	2	3	283	28	112	595
1,222	10"+	10	21	4	1	1	30	4	--	71
Acres	Total	33	151	18	3	4	313	32	112	666

PROPOSED PERMANENT FOREST ZONE

Northwestern Transition Zone - Management Unit 75

1. Black Spruce Site I Working Group:

Thirty-Year Removal Period of the mature and overmature volume and area to be deleted because of flooding:

$$\text{Annual cut by area lost } \frac{5,312}{30} = 177 \text{ Acres}$$

$$\text{Annual cut by volume lost } \frac{16,540}{30} = 551 \text{ Cunits}$$

Theoretical Annual Allowable Cut by Species and Size within Black Spruce Site I Working Group to be deleted from Management Unit 75 because of flooding (in Cunits).

Size	BS	WB	Total
4"-9"	550	--	550
10"+	--	--	--
Total	550	--	550

$$\text{Percent of potential allowable cut lost by volume } \frac{550}{3,940} \times 100\% = 14.0\%$$

Therefore, 14.0% of the annual allowable harvest within the Black Spruce Site I Working Group will be lost due to flooding in Management Unit 75.

Adjusted Total Theoretical Annual Allowable Cut by Species and Size within Black Spruce Site I Working Group in Management Unit 75 (in Cunits).

Size	BS	WB	Total
4"-9"	3,370	20	3,390
10"+	--	--	--
Total	3,370	20	3,390

Black Spruce Site I Working Group

Net Merchantable Volume Lost by Flooding

(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	TL	TA	WB	Total
III 3,637 Acres	4"-9" 10"+ Total	14 -- 14	1,446 28 1,474	1 -- 1	1 -- 1	22 -- 22	1,484 28 1,512
IV 5,022 Acres	4"-9" 10"+ Total	-- -- --	1,550 -- 1,550	2 -- 2	-- -- --	9 -- 9	1,561 -- 1,561
V 290 Acres	4"-9" 10"+ Total	-- -- --	103 1 104	-- -- --	-- -- --	-- -- --	103 1 104
IV & V 5,312 Acres	4"-9" 10"+ Total	-- -- --	1,653 1 1,654	2 -- 2	-- -- --	9 -- 9	1,664 1 1,665
Total 8,949 Acres		14	3,128	3	1	31	3,177

Black Spruce Site I Working Group

Net Merchantable Volume Remaining in M.U. 75

(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	TL	TA	BA	WB	Total
III 39,695 Acres	4"-9"	182	14,981	1	12	134	6	382	15,698
	10"+	1	422	12	--	27	--	--	462
	Total	183	15,403	13	12	161	6	382	16,160
IV 30,849 Acres	4"-9"	--	9,980	--	6	--	--	44	10,030
	10"+	--	--	--	--	--	--	--	--
	Total	--	9,980	--	6	--	--	44	10,030
V 550 Acres	4"-9"	--	111	--	--	--	--	6	117
	10"+	--	--	--	--	--	--	--	--
	Total	--	111	--	--	--	--	6	117
IV & V 31,399 Acres	4"-9"	--	10,091	--	6	--	--	50	10,147
	10"+	--	--	--	--	--	--	--	--
	Total	--	10,091	--	6	--	--	50	10,147
Total 71,094 Acres		183	25,494	13	18	161	6	432	26,307

2. Hardwoods Working Group (All Sites)

It is estimated that a total of 34 acres of Hardwood Working Group stands will be lost due to flooding. No mature volume will be lost as this entire area consists of intermediate-aged volume. No annual cut has been recommended in this working group for the next 15 to 20-year period because of this lack of mature volume. Even after this period, the allowable cut would be minimal owing to the small area of Hardwood growing stock in the Transition Zone.

Therefore, flooding in the Hardwoods Working Group will not influence the total annaul harvest in Management Unit 75.

Hardwoods Working Group (All Sites)
Net Merchantable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	BS	TA	WB	Total
III	4"-9"	1	1	2	4
34	10"+	--	--	--	--
Acres	Total	1	1	2	4

B. Practical Annual Allowable Cut to be Lost Through the Proposed Flooding:

The Practical Annual Allowable Cut is calculated only on the area and volume of mature stands which are feasible to harvest. The volume of the stand must be a minimum of 8 cunits per acre of the four major softwoods (Black Spruce, Jack Pine, White Spruce and Balsam Fir) excluding trees of 4" D.b.h.

The following calculations of Practical cut have been determined by applying a removal period of the mature and overmature Operable volume and associated Operable area. A 12% reduction has been made to all volumes to take care of small scattered stands and fire losses.

The total loss of Practical Annual Allowable Cut for the Project Area is 1,680 cunits over an area of 185 acres. As in the Theoretical Cut, the only working group in which there is a significant loss of allowable cut is Black Spruce I. However, a very small loss will occur in the White Spruce Working Group. Within the Black Spruce Site I Working Group, Black Spruce is the only species that is significantly affected, but very minor annual cuts of Jack and White Spruce are also lost.

Trees 10"+ D.b.h. comprise only 4% of the total volume lost annually while the great majority is found in the 6"-9" Diameter classes. Hence, the material which is removed in clearing operations will be in only the small-to-medium diameter range.

The total loss of Practical Annual Cut is well within the allowable 12% reduction factor built into allowable cut estimates for the area.

CHURCHILL FOREST INDUSTRIES SPECIFIED AREA

Northern Coniferous Zone - Management Unit 64

1. **Black Spruce Site I Working Group:**

Twenty-Year Removal Period of the Net Operable mature and overmature volume and corresponding Operable Area to be deleted because of flooding:

Annual cut by area lost $\frac{314}{20}$ = 16 Acres

Annual cut by volume lost $\frac{3,360}{20}$ = 168 Cunits
(major species of
working group)

Practical Annual Allowable Cut by Species and Size within Black Spruce Site I Working Group (less 12% reduction factor) to be deleted from Management Unit 64 because of flooding (in Cunits).

Size	JP	BS	WS	BF	Total
5"	--	40	--	--	40
6"-9"	20	100	--	--	120
10"+	--	10	10	--	20
Total	20	150	10	--	180

Percent of potential practical allowable cut by volume lost $\frac{180}{55,540}$ x 100% = 0.32%

Adjusted Total Practical Annual Allowable Cut by Species and Size within Black Spruce Site I Working Group (less 12% reduction factor) in Management Unit 64 (in Cunits).

Size	JP	BS	WS	BF	Total
5"	830	11,200	310	60	12,400
6"-9"	5,260	29,090	1,720	150	36,220
10"+	1,650	3,320	1,730	40	6,740
Total	7,740	43,610	3,760	250	55,360

Black Spruce Site I Working Group
Net Operable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting	Size	JP	BS	WS	BF	TA	BA	WB	Total
IV	5"	6	89	1	--	1	--	1	98
313	6"-9"	37	222	9	1	14	1	4	288
	10"+	10	24	10	--	3	1	--	48
Acres	Total	53	335	20	1	18	2	5	434
V	5"	--	--	--	--	--	--	--	--
	6"-9"	--	1	--	--	--	--	--	1
1	10"+	--	--	--	--	--	--	--	--
Acres	Total	--	1	--	--	--	--	--	1
IV & V	5"	6	89	1	--	1	--	1	98
314	6"-9"	37	223	9	1	14	1	4	289
	10"+	10	24	10	--	3	1	--	48
Acres	Total	53	336	20	1	18	2	5	435

Black Spruce Site I Working Group

Net Operable Volume Remaining in M.U. 64

(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	BF	TL	TA	BA	WB	Total
IV	5"	1,858	24,903	696	129	39	842	89	679	29,235
94,515	6"-9"	11,776	64,751	3,839	352	26	4,933	592	1,392	87,661
	10"+	3,702	7,401	3,819	92	6	1,300	235	83	16,638
Acres	Total	17,336	97,055	8,354	573	71	7,075	916	2,154	133,534
V	5"	16	555	4	--	--	13	--	16	604
1,816	6"-9"	187	1,368	73	2	--	39	7	34	1,710
	10"+	51	138	115	2	--	10	7	2	325
Acres	Total	254	2,061	192	4	--	62	14	52	2,639
IV & V	5"	1,874	25,458	700	129	39	855	89	695	29,839
96,331	6"-9"	11,963	66,119	3,912	354	26	4,972	599	1,426	89,371
	10"+	3,753	7,539	3,934	94	6	1,310	242	85	16,963
Acres	Total	17,590	99,116	8,546	577	71	7,137	930	2,206	136,173

2. **White Spruce Working Group (All Sites):**

Only 17 acres of Operable area in this working group will be affected by flooding in Management Unit 64. This amount is insignificant as it constitutes less than 3% of the 630 acres of operable area within the working group in the entire unit. Therefore, no loss of annual cut has been estimated for White Spruce.

White Spruce Working Group (All Sites)
Net Operable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	BF	TA	WB	Total
IV	5"	--	1	2	1	--	--	4
17	6"-9"	1	5	8	2	1	1	18
	10"+	--	1	11	--	1	1	14
Acres	Total	1	7	21	3	2	2	36

PROPOSED PERMANENT FOREST ZONE

Northern Coniferous Zone - Management Units 71, 72 and 73

1. Black Spruce Site I Working Group:

Twenty-Year Removal Period of the Net Operable mature and overmature volume and corresponding Operable area to be deleted because of flooding.

Annual cut by area lost $\frac{3,378}{20}$ = 169 Acres

Annual cut by volume lost $\frac{33,170}{20}$ = 1,659 Cunits
(major species of
working group)

Practical Annual Allowable Cut by Species and Size within Black Spruce Site I Working Group (less 12% reduction factor) to be deleted from Management Units 71, 72 and 73 because of flooding (in Cunits).

Size	JP	BS	WS	Total
5"	--	480	--	480
6"-9"	10	900	20	930
10"+	--	80	10	90
Total	10	1,460	30	1,500

Adjusted Total Practical Annual Allowable Cut by Species and Size within Black Spruce Site I Working Group (less 12% reduction factor) in Management Units 71, 72 and 73 (in Cunits).

Size	JP	BS	WS	Total
5"	--	2,090	--	2,090
6"-9"	30	4,160	70	4,260
10"+	--	410	60	470
Total	30	6,660	130	6,820

Black Spruce Site I Working Group
Net Operable Volume Lost by Flooding

(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	TL	TA	WB	Total
IV	5"	--	742	2	--	1	12	757
2,386	6"-9"	4	1,481	40	1	--	19	1,545
	10"+	--	149	25	--	--	--	174
Acres	Total	4	2,372	67	1	1	31	2,476
V	5"	--	345	--	--	--	1	346
	6"-9"	--	566	2	--	--	3	571
992	10"+	--	34	12	--	--	--	46
Acres	Total	--	945	14	--	--	4	963
IV & V	5"	--	1,087	2	--	1	13	1,103
3,378	6"-9"	4	2,047	42	1	--	22	2,116
	10"+	--	183	37	--	--	--	220
Acres	Total	4	3,317	81	1	1	35	3,439

Black Spruce Site I Working Group

Net Operable Volume Remaining in M.U.s 71, 72 & 73

(in Thousands of Cubic Feet)

Cutting Class	Size	JP	BS	WS	TL	TA	WB	Total
IV	5"	10	4,397	6	--	8	74	4,495
14,248	6"-9"	79	8,863	152	4	--	115	9,213
	10"+	2	900	115	--	--	--	1,017
Acres	Total	91	14,160	273	4	8	189	14,725
V	5"	--	358	--	--	--	2	360
1,029	6"-9"	--	587	2	--	--	3	592
	10"+	--	36	12	--	--	--	48
Acres	Total	--	981	14	--	--	5	1,000
IV & V	5"	10	4,755	6	--	8	76	4,855
15,277	6"-9"	79	9,450	154	4	--	118	9,805
	10"+	2	936	127	--	--	--	1,065
Acres	Total	91	15,141	287	4	8	194	15,725

2. White Spruce Working Group (All Sites)

In this section of the Project Area there are only 68 operable acres in the White Spruce Working Group. Twenty-seven acres of this operable area will be lost through flooding. No allowable cut estimates will be calculated for this working group as the area involved is insignificant and cannot be adapted to sustained yield management.

White Spruce Working Group (All Sites)
Net Operable Volume Lost by Flooding
(in Thousands of Cubic Feet)

Cutting Class	Size	BS	WS	WB	Total
IV	5"	2	4	1	7
27	6"-9"	14	19	--	33
	10"+	2	8	--	10
Acres	Total	18	31	1	50

C. Summary of Theoretical and Practical Annual Allowable Cut to be Lost:

Summaries of Theoretical and Practical Annual Allowable Cut to be lost through the proposed flooding are presented in Tables XV, XVI and XVII.

TABLE XV

Southern Indian Lake Project Area

Summary of Potential Loss of Theoretical Annual Allowable Cut Through Proposed Flooding

-By Zones, Working Group and Species-

(in Cunits)

Zone	Working Group	Period in Years	Area in Acres	Jack Pine	Black Spruce	White Spruce	Sub Total	Trembling Aspen	White Birch	Sub Total	Grand Total
Churchill Forest Ind. Specified Area - Northern Coniferous Zone M.U. 64	Black Spruce Site I	20	16	40	200	10	250	10	--	10	260
	White Spruce	--	--	--	Insignificant Quantity				--	--	--
	Hardwoods	--	--	--	Insignificant Quantity				--	--	--
	Sub-Total	--	16	40	200	10	250	10	--	10	260
Proposed Permanent Forest Zone-Northern Coniferous Zone M.U.s 71, 72 & 73	Black Spruce Site I	20	235	10	2,390	40	2,440	--	30	30	2,470
	White Spruce	--	--	--	Insignificant Quantity				--	--	--
	Sub-Total	--	235	10	2,390	40	2,440	--	30	30	2,470
Proposed Permanent Forest Zone-Northwestern Transition Zone-M.U. 75	Black Spruce Site I	30	177	--	550	--	550	--	--	--	550
	Sub-Total	--	177	--	550	--	550	--	--	--	550
Entire Southern Indian Lake Project Area	Black Spruce Site I	--	428	50	3,140	50	3,240	10	30	40	3,280
	White Spruce	--	--	--	Insignificant Quantity				--	--	--
	Hardwoods	--	--	--	Insignificant Quantity				--	--	--
	Grand Total	--	428	50	3,140	50	3,240	10	30	40	3,280

TABLE XVI

Southern Indian Lake Project Area

Summary of Potential Loss of Practical Annual Allowable Cut Through Proposed Flooding

-By Zone, Working Group and Species-

(in Cunits)

Zone	Working Group	Period in Years	Area in Acres	Jack Pine	Black Spruce	White Spruce	Total Softwood
Churchill Forest Ind. Specified Area Northern Coniferous Zone M.U. 64	Black Spruce Site I	20	16	20	150	10	180
	White Spruce	--		Insignificant Quantity			--
	Sub-Total	--	16	20	150	10	180
Proposed Permanent Forest Zone-Northern Coniferous Zone M.U.s 71, 72 & 73	Black Spruce Site I	20	169	10	1,460	30	1,500
	White Spruce	--		Insignificant Quantity			--
	Sub-Total	--	169	10	1,460	30	1,500
Proposed Permanent Forest Zone-Northwestern Transition Zone-M.U. 75	N I L						
Entire Southern Indian Lake Project Area	Black Spruce Site I	--	185	30	1,610	40	1,680
	White Spruce	--		Insignificant Quantity			--
	Grand Total	--	185	30	1,610	40	1,680

TABLE XVII

Southern Indian Lake Project Area

Summary of Potential Loss of Practical Annual Allowable Cut Through Proposed Flooding

-By Zone, Working Group, Species and Diameter Group-

(in Cunits)

Zone	Working Group	Species	Jack Pine			Black Spruce			White Spruce		
		Diameter	5"	6"-9"	10"+	5"	6"-9"	10"+	5"	6"-9"	10"+
Churchill Forest Ind. Specified Area-Northern Coniferous Zone-M.U. 64	Black Spruce Site I		--	20	--	40	100	10	--	--	10
	White Spruce		--	--		Insignificant Quantity				--	--
	Sub-Total by Diameter		--	20	--	40	100	10	--	--	10
	Sub-Total by Species			20			150			10	
Proposed Permanent Forest Zone-Northern Coniferous Zone M.U.s 71, 72 & 73	Black Spruce Site I		--	10	--	480	900	80	--	20	10
	White Spruce		--	--		Insignificant Quantity				--	--
	Sub-Total by Diameter		--	10	--	480	900	80	--	20	10
	Sub-Total by Species			10			1,460			30	
Proposed Permanent Forest Zone-Northwestern Transition Zone-M.U. 75						N I L					
Entire Southern Indian Lake Project Area	Black Spruce Site I		--	30	--	520	1,000	90	--	20	20
	White Spruce		--	--		Insignificant Quantity				--	--
	Grand Total by Diameter		--	30	--	520	1,000	90	--	20	20
	Grand Total by Species			30			1,610			40	

APPENDIX II

Glossary of Terms

Glossary

Brush and Shrub (815) - Areas of private and leased land only, cleared of tree cover for future agricultural use, temporarily covered with brush, shrubs, etc.

Barren-Bare Rock (800) - Tundra and rock with less than 25 percent tree cover.

Cover Type - Four broad cover types are recognized - Softwood "S", Softwood-Hardwood "M", Hardwood-Softwood "N", Hardwood "H". The first number of the type aggregate code indicates the cover type.

Code - 0-3 - Softwood - "S" - includes all stands where at least 76 percent of the total basal area consists of coniferous species.

4-7 - Softwood-Hardwood Mixedwood - "M" - includes all stands where the basal area of all the coniferous species is between 51 percent and 75 percent of the total basal area.

8 - Hardwood-Softwood Mixedwood - "N" - includes all stands where the basal area of all coniferous species is between 26 percent and 50 percent of the total basal area.

9 - Hardwood - "H" - includes all stands where the basal area of all coniferous species is less than 25 percent of the total basal area.

The above cover types are determined by the percent of basal area of softwood in proportion to the total basal area found on all plots taken within a stand.

Crown Closure - This is a stand density estimate made by a photointerpreter. Crown Closure is the percentage of the ground within a stand covered by the crowns of trees located within the stand. The following crown closure classes are recognized in Manitoba:

Forest Regions 1, 2, 4 and 5 and the Whiteshell

Code

0 - applies to potential productive stands only
1 - 15% to 30% crown closure
2 - 31% to 50% crown closure
3 - 51% to 70% crown closure
4 - 71% and over

Forest Regions 3, 6, 7, 8 and 9 excluding the Whiteshell

Code

0 - 0 to 20% crown closure
2 - 21 to 50% crown closure
3 - 51 to 70% crown closure
4 - 71% and over

Cull Factors - Percentage reduction factors by diameter group applied to Gross Merchantable Volume to obtain Net Merchantable Volume. The factors are based on expected and known losses due to decay, damage and shape by species and diameter group. The following factors apply to Forest Regions 3, 5, 6, 7, 8 and 9.

Species	4"-9" D.b.h.	10"+ D.b.h.
Jack Pine	10%	15%
Black Spruce	5%	10%
White Spruce	5%	10%
Balsam Fir	15%	25%
Tamarack Larch	10%	10%
Hardwoods	20%	40%

Cutting Class - This is a designation applied to forest stands based on size, vigour, state of development and maturity of a stand for harvesting purposes. Five cutting classes are recognized as follows:

Cutting Class 0 - Forest land not restocked following fire, cutting, windfall, or other major disturbances (hence, potentially productive land). Some reproduction or scattered residual trees (with net merchantable volume less than 2.5 cunits per acre may be present).

Cutting Class 1 - Stands which have been restocked either naturally or artificially. There may be scattered residual trees present as in Cutting Class 0. To be in Cutting Class 1, the average height of the stand must be less than 12 feet.

Cutting Class 2 - Advanced young growth of post size, with some merchantable volume. The average height of the stand must be over 12 feet in order to be in this cutting class.

Cutting Class 3 - Immature stands with merchantable volume growing at or near their maximum rate, which definitely should not be cut. The average height of the stand should be over 25 feet and the average diameter should be over 3.6 inches at D.b.h.

Cutting Class 4 - Mature stands which may be cut as they have reached rotation age (± 10 years or ± 20 years on Site 2 black spruce, tamarack larch and eastern cedar).

Cutting Class 5 - Overmature stands which should be given priority in cutting due to susceptability to decay, natural damage and insect attack.

Diameter Breast Height (D.b.h.) - The diameter of a tree measured at breast height (4.5 feet above ground level). Measurement at this point gives a diameter free from butt swell and is a convenient standard point for measurement. Volume estimates are based on diameter at breast height.

Fields (Agriculture) (810) - Areas of private and leased land cleared of tree cover and presently under an agricultural use.

Forest Management Unit - The Forest Management Unit is the basic unit of area considered for Forest Inventory purposes. Forest Management Units have been established on a variety of situations including: status and ownership, administrative units, accessibility, acceptable size and/or forest cover variations.

Forest Regions - There are 9 Forest Regions in the Forest Zone of the Province of Manitoba. Forest Regions have been established based on physical geography and administrative boundaries. Each Forest Region has been further subdivided into Forest Management Units as follows:

1 - Mountain Forest Region - Forest Management Units 11-15

2 - South East Forest Region - Forest Management Units 20-29

3 - Lake Winnipeg East Forest Region - Forest Management Units 30-39

4 - Lowland South Forest Region - Forest Management Units 40-49

5 - Lowland North Forest Region - Forest Management Units 51-57

6 - Northern Mining Forest Region - Forest Management Units 60-66

7 - Northern Transition Forest Region - Forest Management Units 71-75

8 - Nelson River Forest Region - Forest Management Units 81-89

9 - North East Forest Region - Forest Management Units 90-99

0 - Agriculture - Units 01-09

Forest Zone - The Forest Zone is the area which is producing or capable of producing forest crops and which for climatic reasons, is in the main, more suitable for the production of forests than for agricultural crops. The definition of the Forest Zone boundary is essentially the same as the definition of the Wooded District Boundary as presented in "The Fires Prevention Act" of the Province of Manitoba (R.S.M. 1954, Chapter 86).

Gross Merchantable Volume - This is the volume of all species with diameters 3.6" D.b.h. and larger and is found to a specified top diameter and a stump height of one foot. For spruce and pine, top diameter is 3"; for all other species, it is four inches. Volume only in Cutting Classes 3, 4 and 5 is considered.

Increment - annual or periodic increase in volume of a tree or a stand.

Ingrowth - increase of the merchantable volume of a stand as the result of non-merchantable trees (less than 3.5 inches D.b.h.) becoming merchantable during a period of time under consideration.

Marsh-Muskeg (830) - Marsh - Wet lands completely or partially covered with tall grass, rushes or sedges, unsuitable for hay, but can be used as a habitat for fur-bearing animals.

Muskeg - Wet land which has a vegetative cover consisting mainly of sphagnum moss and heath plants with very scattered brush. Black spruce, tamarack or cedar cover does not exceed 25%.

Mud and salt flats around lakes.

Meadow (820) - Moist to wet grassland suitable for hay production (natural hay land).

Mean Annual Increment - The total volume increment up to a given age divided by the age.

Merchantable Volume - The volume of the portion of a tree without bark, excluding the stump (12 inches high) and the top with the bottom diameter of 3 inches inside bark. Merchantable volume of a stand is the sum of the merchantable volume of all trees found in a stand.

Net Merchantable Volume - The Gross Merchantable Volume of all species with diameters 3.6" D.b.h. and larger less the respective cull factors. See Cull Factors.

Net Operable Volume - The Net Merchantable Volume of all operable stands. An operable stand is one which contains a minimum of 800 or greater cubic feet per acre in Cutting Classes 4 and 5 only of the four major Softwood species (Jack Pine, Black Spruce, White Spruce and Balsam Fir) excluding trees 4" D.b.h.

Non-Forested Land - Includes areas a) withdrawn from timber production for a long period of time, such as cultivated fields, hay meadows, pastures, settlements, rights-of-way, gravel pits, beaches, wide ditches, summer resorts, and b) not capable of producing merchantable timber, such as rock, barren, mines, marsh and muskeg.

Non-Productive Forested Land - Includes all forest land not capable of producing merchantable timber due to very low productivity.

Option Area - The area under examination in an Option Licence.

Option Licence - The Minister, with the approval of the Lieutenant-Governor-in-Council and after giving public notice, may issue an option licence to a forest industry for a forest area for a period not exceeding two years in order that the person to whom such a licence is issued may have an opportunity to make examinations and surveys to determine whether or not he wishes to obtain a forest management licence for all or part of such area, and the minister may forbid or restrict the issuance of any other timber licence or permit in the area covered by the Option Licence.

Ownership - The following ownerships of land within the Province of Manitoba are recognized:

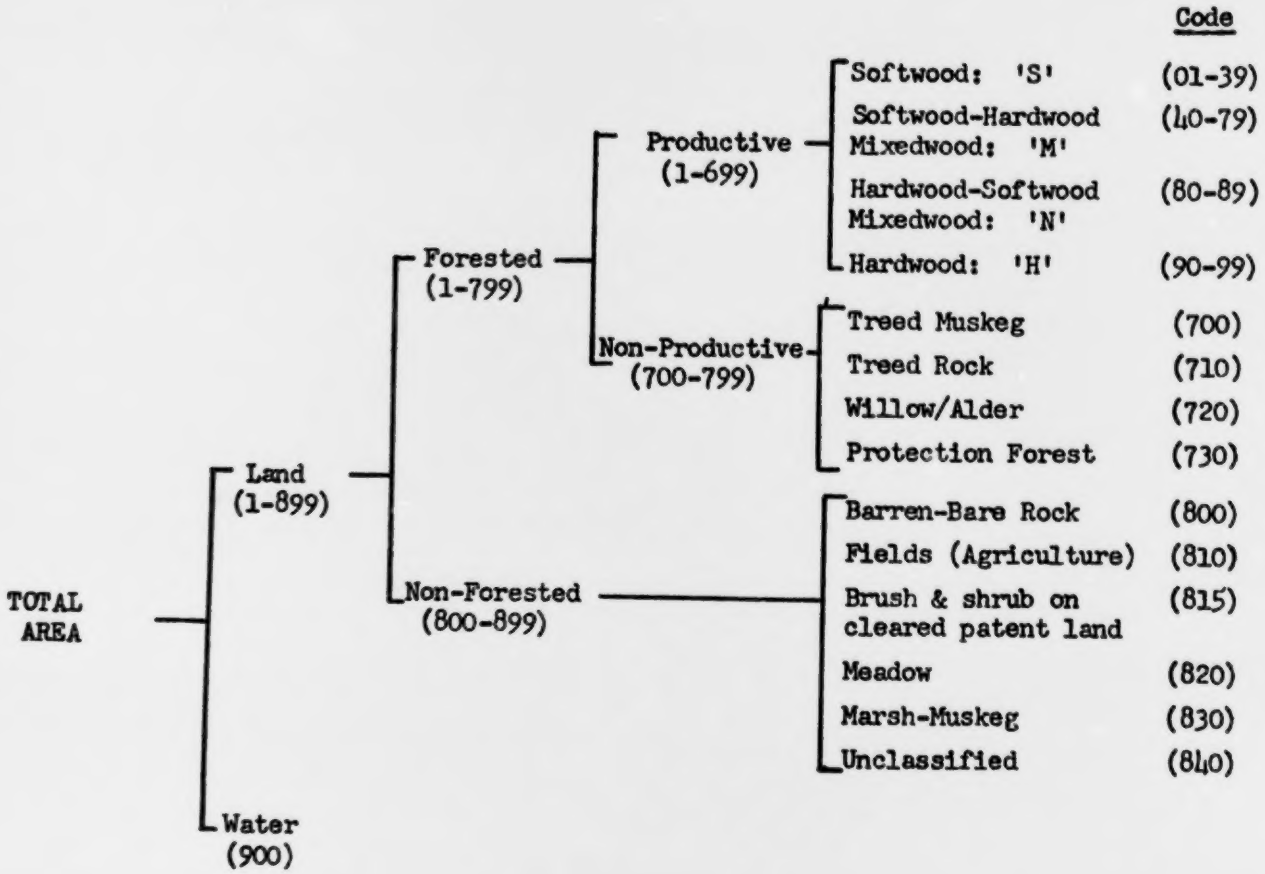
Provincial Crown Land - Closed to forest operations	0
Provincial Crown Land - Open to forest operations	1
Provincial Crown - Restricted to forest operations	2
Federal Crown Land	3
Patented (Private) Land	5
Local Government District Land	6
Indian Reserve	7
Other	9

Potential Productive Forest Land - Includes forest land capable of producing merchantable timber, cut temporarily not producing, such as recent burn, clear-cut, or windstorm.

Practical Annual Allowable Cut - This is the amount of timber, by volume or area, based on net operable volume and area that can be cut each year on a sustained yield basis. A 12% reduction is made to all volumes as an allowance for no-cut zones, small scattered stands and fire losses.

Productive Forested Land - Includes all forest land capable of producing merchantable wood within rotation age regardless of its existing stage of productivity.

Productivity - The following diagram indicates the productivity breakdown:


Code
TOTAL AREA
Land (1-899)
Water (900)
Forested (1-799)
Non-Forested (800-899)
Productive (1-699)
Non-Productive (700-799)
Softwood: 'S' (01-39)
Softwood-Hardwood Mixedwood: 'M' (40-79)
Hardwood-Softwood Mixedwood: 'N' (80-89)
Hardwood: 'H' (90-99)
Treed Muskeg (700)
Treed Rock (710)
Willow/Alder (720)
Protection Forest (730)
Barren-Bare Rock (800)
Fields (Agriculture) (810)
Brush & shrub on cleared patent land (815)
Meadow (820)
Marsh-Muskeg (830)
Unclassified (840)

Specified Area - All lands (less exceptions) owned by the Province within an area in Northern Manitoba effective April 1, 1966 as defined on Page 3 of the Memorandum of Agreement entered into on February 24, 1966 between the Province of Manitoba and Churchill Forest Industries (Manitoba) Limited. The forests located on the lands so defined were set aside to assure the required wood supply for the forest complex at The Pas, Manitoba.

Status - The term 'status of land' is used to indicate present or proposed committments on the following basis:

Status of Land	Code
Agricultural Zone	0
Provincial Forest	1
Proposed Permanent Forest	2
Licence Berths	4
Pulpwood Berths	5
Specified Areas - Timber Berths	6
Provincial Park	7
INCO Land	8
Agricultural land within the wooded area	9

Subtype - This term indicates the species composition in broad groups within the cover type. Subtype is determined by the proportion of basal area of two or three main species in the stand as found on a sample plot to the total basal area of all species. To determine the subtype, the basal area of indiviual species must be computed and rounded off to the nearest one percent.

Theoretical Annual Allowable Cut - This is the amount of timber, either by volume or area, based on net merchantable volume that can be cut each year on a sustained yield basis.

Treed Muskeg (700) - This is similar to open muskeg, except that the area is supporting semi-stagnated or stagnated trees. Some of the trees may produce "Christmas" trees or fence posts, but will not produce pulpwood size trees or fence posts within a rotation age of 140 years (4"+ D.b.h., height over 30 feet and 2.5 cords of net merchantable volume per acre). At least 26% of the area will be tree-covered.

Treed Rock (710) - Rock with a very shallow soil, supporting semi-stagnated or stagnated trees. At least 26 percent of the area will be tree-covered. These sites do not produce merchantable stands.

Type Aggregate - This term is used in reference to all stands or potentially productive areas in a Management Unit or Forest Section which have common characteristics as to cover type, subtype, site, cutting class, and crown closure.

Unclassified (840) - Rights-of-way, roads, gravel pits, beaches, summer resorts, mines, etc.

Water (900) - Includes lakes and rivers, measured at the high-water mark, able to be delineated on the aerial photographs. Narrow rivers and creeks are not to be considered as separate types, nor as type boundaries.

Willow/Alder (720) -	Low-lying areas with a saturated water table presently supporting willow or alder growth. Without improvement these sites are not capable of producing merchantable timber stands.
Working Group -	This term is used in reference to all stands or potentially productive areas on the same site and with the same predominant species.

APPENDIX 3 - F
THE EFFECTS OF INCREASING LAKE LEVELS ON FORESTS ADJACENT TO NEW SHORELINES

THE EFFECTS OF INCREASING LAKE LEVELS ON FORESTS ADJACENT TO NEW SHORELINES

by

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Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba
March, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

ABSTRACT

This project investigated the reaction of existing tree cover to the probable changed soil moisture condition along the shore of two existing reservoirs, Cedar-Cross and Sipiwesk Lakes. Radial increments of trees from a variety of sites were compared before and after flooding. Jack pine, white spruce and black spruce were the species investigated. Soil pits were usually dug in an attempt to locate the water table. The study was designed to enable inferences as to the future effects of flooding on the growth of trees adjacent to the new shoreline of the Jenpeg forebay.

No adverse effects on tree growth were found resulting from an increased lake level. Of interest was the fact that the dead line for aspen, balsam poplar and willow was lower on the slope than for pine and spruce, indicating that these hardwood species have a greater tolerance to flooding. Further research into this phenomenon would prove useful to agencies who wish to maintain a woody vegetation cover on periodically flooded land.

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SUMMARY SECTION

Recommendations

This study did not find any areas of concern with respect to the effects of increasing lake levels on forests adjacent to new shores. Further research could be done, however, into the flood resistance of willow, aspen and balsam poplar plus exotic species if there are periodically flooded areas where it is desirable to maintain a woody vegetation cover.

Objectives

The objective of this study was to determine if increased water levels in reservoir creation would affect the growth of timber adjacent to new shores.

Terms of Reference

The study was conducted on two reservoirs in the province, Cedar-Cross and Sipiwesk Lakes. Sampling was designed to enable inferences as to the future effects of flooding on the growth of jack pine, white and black spruce adjacent to the new shoreline of the Outlet Lakes which will be flooded by a control structure at Jenpeg.

Study Area

The study areas were Cross and Sipiwesk Lakes whose levels are controlled by dams at Grand Rapids and Kelsey respectively. The accessible forests around Cross Lake are predominantly jack pine while those at Sipiwesk Lake are mainly spruce forests. The geology of the two sites varies. The Cross Lake area is underlaid by limestone bedrock with an overburden of calcareous glacial till. The Sipiwesk Lake area, on the other hand, is underlaid mainly by precambrian bedrock with a covering of varved lacustrine clay.

Methodology

Forest sites for sampling were chosen in proportion to those of the future shoreline of the Jenpeg forebay. Two lines in jack pine were sampled at Cross Lake, four lines in pure black spruce and four in mixed black spruce stands were sampled at Sipiwesk Lake. Shore slope and accessibility were considerations in line selection. Line starts were randomly established.

A line consisted of five sample points, the first at the spruce-pine dead line; succeeding points were 50 feet apart with a minimum of 100 feet between the last two points. At each point a soil pit was dug and two trees were felled. Annual radial increments for the last 30 years were measured at stump height and 4.5 feet above the ground. Compilation was carried out only on data collected at the higher point. The refined data compares average annual increments of the post flooding period with those of an adjacent equal preflooding period for each tree.

Qualitative observations were made concerning the differential dying of species and other points considered to be of interest along each line.

Observations and Conclusions

A total of 95 trees were felled in the study. Of this number, only five had preflooding increments less than post flooding increments regardless of shore slope, depth to water table or proximity to the new shore. Three of the five deviations from the normal could be easily explained. On this basis it was concluded that a change in proximity to the shore had no adverse effect on the growth of jack pine and spruce. This was in agreement with findings for other species (Green 1947).

It has been shown that several tree species will put down normal annual increments after flooding but when death comes it is sudden (Green 1947). An indication that this may be true for white spruce was found at Sipiwesk Lake.

The differential dying of species was noted at both study sites. Wherever aspen, balsam poplar and willow were present with pine or spruce, the dead line for the hardwood species was always lower on the slope than the conifer dead line. This phenomenon indicates that research into the maintaining of a woody vegetation cover on periodically flooded land may be fruitful. Studies along these lines have been carried out in Europe (Gill, 1970).

The greatest current damage being done to trees is of a localized nature at Sipiwesk Lake. Here, the raised lake level created new headlands which are actively eroding. Undercutting has progressed to the point where trees are falling into the lake.

The Effects of Increasing Lake Levels on Forests Adjacent to New Shorelines

by R. F. Calvert

COMPREHENSIVE REPORT

I RECOMMENDATIONS

This study did not find any areas of concern with respect to the effects of increasing lake levels on forests adjacent to new shores.

The feasibility of maintaining a vegetation cover on areas which are unsightly during periods of low reservoir levels but are flooded with frequency could be fruitfully investigated. Certain native species demonstrated an ability to withstand periodic flooding but survival limits are unknown; to determine these would require an in-depth research input. Recreation areas would be a prime concern here.

II OBJECTIVES

The creation of reservoirs for any purpose almost always results in the flooding of land. The increased water levels will probably have an effect on the ground water status of the soils adjacent to the new shore and perhaps on the growth of trees growing there. This project investigated the reaction of existing tree cover to the probable changed moisture condition along the shore of two existing reservoirs, Cedar-Cross and Sipiwesk Lakes.

III TERMS OF REFERENCE

The study was designed to enable inferences as to the future effects of flooding on the growth of trees adjacent to the new shoreline of the Outlet Lakes (Figure 1) which will be flooded by a control structure at Jenpeg. Sampling was restricted to jack pine (Pinus banksiana Lamb(= P. divaricata (ait.) Dumont)), white spruce (Picea glauca (Moench) Voss) and black spruce (P. mariana (Mill.) B.S.P.) growing above the dead line of the Cedar-Cross and Sipiwesk Lakes reservoirs on sites similar to those of the new shoreline of the Outlet Lakes.

Ground vegetation was just qualitatively observed and noted on the tally sheets. The reason for this was the length of time since flooding and the relatively short life-span of these plants. Under such circumstances a detailed investigation would not yield much useful information.

IV STUDY AREA

The areas investigated (Figure 1) were various sites adjacent to new shorelines of Cross and Sipiwesk Lakes whose levels have been controlled by dams at Grand Rapids and Kelsey respectively. The Grand Rapids dam was closed in August, 1964 and the forebay considered full in the early spring of 1965; corresponding dates for Kelsey are November 1960 and probably December 1960. The level of Cross Lake went up approximately 10 feet and the level of Sipiwesk Lake went up approximately four feet (Manitoba Hydro 1973).

Forest Cover Types

The forest stands with a high conifer component adjacent to the new shore of the Outlet Lakes will contain mostly jack pine, white spruce and black spruce either as pure stands or in combination with each other and often with aspen (Populus tremuloides Michx.) and balsam poplar

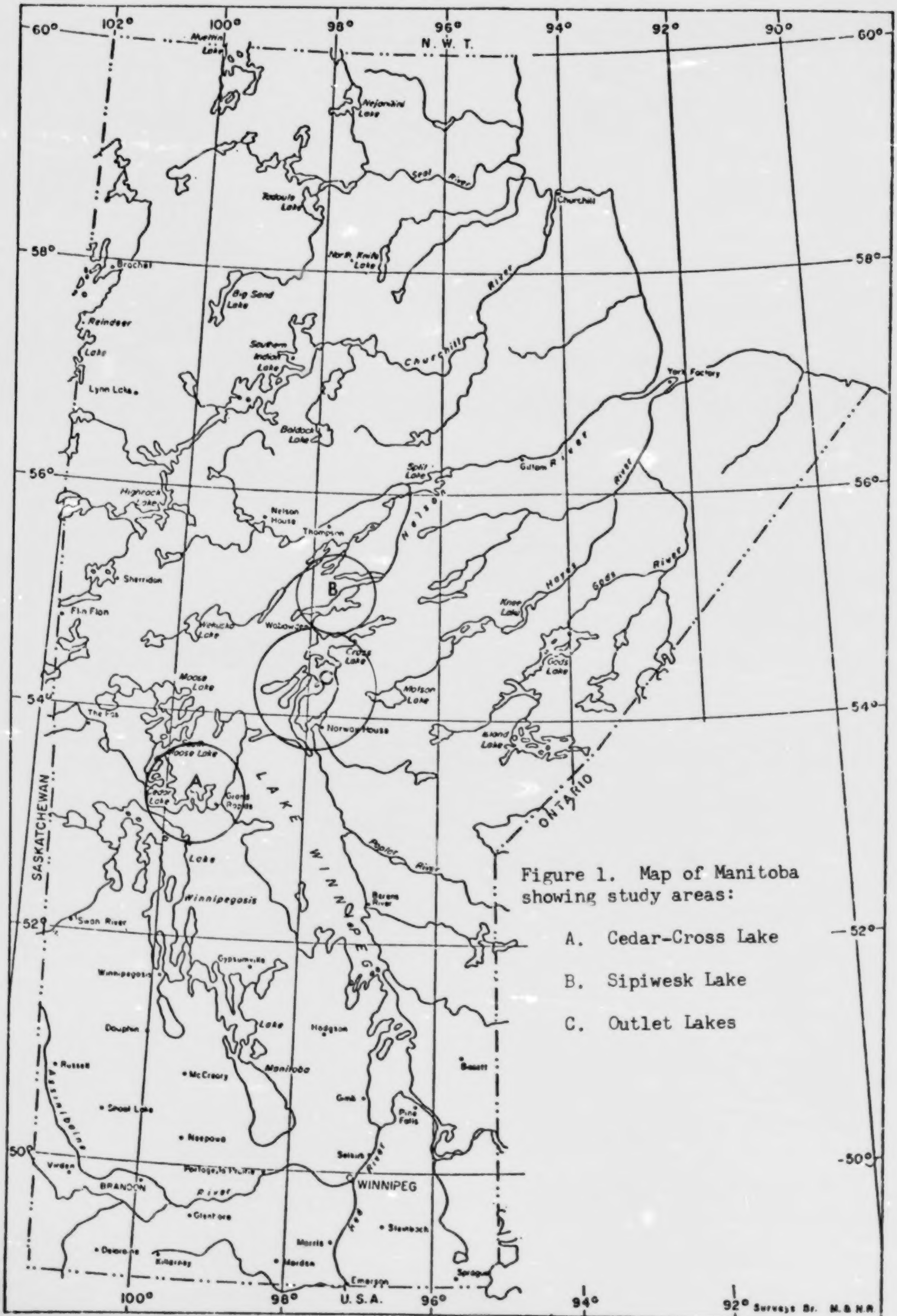
60°
102°
100°
98°
96°
94°
92°
90°
N. W. T.
Nejanilini Lake
Seal River
Tadoule Lake
Churchill
North Knife Lake
58°
Brochet
Big Sand Lake
Reindeer Lake
Southern Indian Lake
Churchill River
Lynn Lake
York Factory
Baldock Lake
56°
Split Lake
Gillam
Nelson River
Highrock Lake
Nelson House
Thompson
B
Sherridon
Flin Flon
Wabowden
Cross Lake
C
Knee Lake
Hayes River
Gods River
Gods Lake
Molson Lake
54°
Moose Lake
The Pas
Norway House
Island Lake
South Moose Lake
A
Cedar Lake
Grand Rapids
LAKE WINNIPEG
ONTARIO
SASKATCHEWAN
Poplar River
Lake Winnipegosis
Berens River
52°
Swan River
Gypsumville
Winnipegosis
Dauphin
Lake Manitoba
Hodgson
Russell
McCreary
Bissett
Shoal Lake
Gimli
Pine Falls
Neepawa
50°
Virden
Portage la Prairie
Selkirk
BRANDON
Assiniboine River
WINNIPEG
Red River
Glenboro
Steinbach
Deloraine
Morris
Killarney
Morden
Emerson
Sprague
U.S.A.
Surveys Br. M. & N.R.

Figure 1. Map of Manitoba showing study areas:

A. Cedar-Cross Lake

B. Sipiwesk Lake

C. Outlet Lakes

(P. balsamifera L) (Manitoba Forest Inventory 1972). The most predominant stands are spruce types. The accessible forests of the Cedar-Cross Lake area are mainly jack pine types while the major accessible cover types around Sipiwesk Lake have a high spruce component with relatively little jack pine.

Geology

The bedrock of the Outlet and Sipiwesk Lakes area is mainly precambrian granites or the product of their metamophosism. The overlying landform is a lacustrine plain composed of varved silts or clays (Figure 2). The deposits vary in thickness up to 100 feet (Gill 1959).

Figure 2. Varved lacustrine silts and clays at Sipiwesk Lake;

The bedrock of the Cedar-Cross Lake area is highly fractured limestone (Figure 3) with an overburden of calcareous boulder till. The landform feature is a till plain.

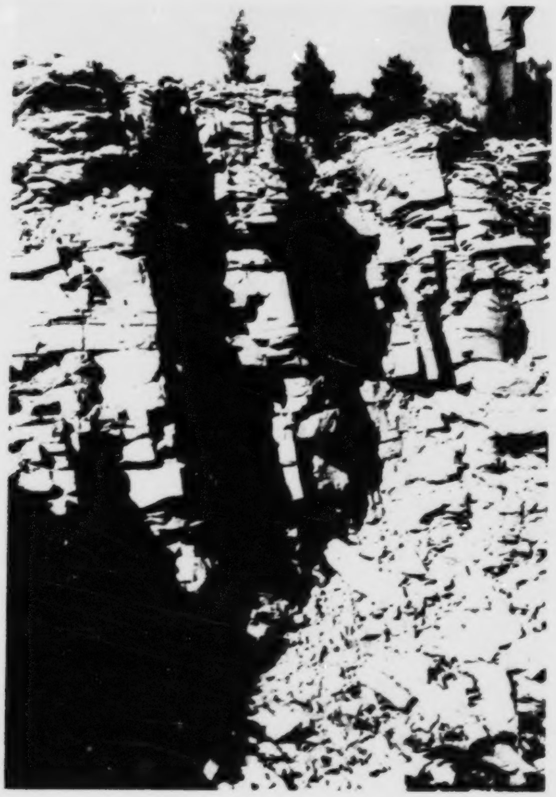

Figure 3. Highly fractured limestone bedrock of the Cedar-Cross Lake area.

The major soils of both regions would fall in the Brunisolic and Luvisolic Orders and would have sandy loam to clay textures.

V METHODOLOGY

Sampling

The sample consisted of 10 lines of five plots. Two lines were examined at Cross Lake (Appendix 1) and eight lines at Sipiwesk Lake

(Appendix 11). The distribution of the sample was arrived at comparing the forest cover type proportions adjacent to the new shoreline of the Jenpeg forebay with those adjacent to the new shorelines of Cross and Sipiwesk Lakes. On this basis, two lines in jack pine, (Cross Lake), four lines in pure black spruce and four lines in mixed black spruce stands (Sipiwesk Lake) were chosen for sampling. An attempt was made to select a variety of sites ranging from minimum to maximum slope. Line starts were randomly established. Degree of access was considered in selection.

The coniferous dead line was taken at the starting point for each line and the first plot established here. The line was run approximately perpendicular to contours of altitude; plots were established usually at 50 ft. intervals along the line with 100 ft distance between the last two plots. At each plot on the line a soil pit was usually dug and two coniferous trees felled and sectioned at d.b.h.[1] At each cut point on the stem, growth ring widths along an average radius were measured to the nearest half of 1/40 inch from the pith outward for the last 30 years of growth. These two points were chosen because growth rings at stump level are among the largest on the tree and perhaps a slight growth defect would be more easily detected here than at any other spot up the stem, and at d.b.h. because Provincial Forest Inventory volume tables are constructed on diameters measured at this level. Any changes detected here could then be related to stand volume changes. No height growth measurements were taken because at Cross Lake, shoreline tree height was affected by exposure and at Sipiwesk Lake current annual height growth of trees sampled was 3 in. - 6 in. Thus it was not practical to attempt to collect this data.

[1] d.b.h. (Diameter at breast height) is a universal tree measurement term where stem diameter is measured 4.5 feet above the ground.

Qualitative observations were made concerning the differential dying of species and other points thought to be of interest along each line.

The field work was completed during the month of June, 1972.

Treatment of Data

Preliminary inspection of the data indicated that stump increment information contributed nothing to the study and it was set aside. Effort was concentrated on measurements taken at d.b.h. because of the universality of this measurement position. Data from all lines was compiled and is presented in tabular form. The refined data compares average annual increments of the post flooding period with those of an adjacent equal preflooding period.

The average annual increment was calculated for each sample tree. Point averages were not determined because species and/or age of the tree often varied. Trees of unequal ages cannot be averaged because the curve of cumulative annual radial (or diameter) growth plotted over age is sigmoid in shape (Chapman and Meyer, 1949). Thus comparisons between unequal aged trees can only be made in the relative sense unless it can be shown that the trees are in similar stages of growth as defined by their individual curve shapes. The combining of species is also unwise because different species probably react differently to stress i.e. what is toxic to one species may not be to another.

Qualitative observations are noted with the presentation of increment data.

VI OBSERVATIONS

Cross Lake

The refined data collected at Cross Lake are presented in Tables 1 and 2. The average before and after flooding increments indicate that tree growth was not affected by a change in their proximity to the shore. In almost every instance post flooding growth was greater than pre flooding growth. Exceptions to this trend are indicated in Table 1(tree 1, point 1 and 4) and Table 2 (tree 1, point 5). These trees averaged less annual growth after than before flooding. The first two trees (Table 1) are relics which survived a fire about 30 years ago and are mature for the site. When the cumulative annual increments of these two trees are plotted over age, the curve shape (not presented here) was that of the terminal half of a sigmoid curve; the rate of annual growth beginning to fall off 8 to 10 years ago. The third tree (Table 2) was growing on a thin patch of soil on exposed bedrock and was growing surprisingly well considering this fact.

A tree of interest is shown in Figure 4 (Table 2, point 1, tree 2). This tree is growing virtually on the dead line and yet has shown no signs of a modified growth rate.

Three observations of general interest are: 1) where they exist, the aspen and willow (Salix sp.) dead line is well below the pine dead line (Table 2); 2) the dead trees of small diameter at the start of line 2 (Table 2) have begun to fall down (Figure 5); and 3) signs of beach building (sand accumulation) is evident in the areas where the trees have fallen.

Sipiwesk Lake

Growth trends at Sipiwesk Lake (Tables 3 to 10) closely follow those at Cross Lake. The average ring widths of these samples are approximately half the width of Cross Lake samples. The trees sampled

Figure 4. Jack pine dead line, Cedar Lake. The axe is implanted in a living tree, the tree to the left is dead. The other woody vegetation is living willow.

Figure 5. The dead trees at the start of line 2, Cross Lake.

at Sipiwesk Lake are on an average, 83 years old as compared to the Cross Lake sample with an average age of 31 years. The older trees are near maturity and the narrow rings are characteristic of this stage of growth. This makes differences more difficult to determine; even so in only two samples (Table 10, point 1) in 80 was mean increment after flooding less than the corresponding measure before flooding. The departure from the normal trend of the two trees cannot be explained by tree age or growing situation but the differences are very small and not thought to be significant.

The greatest current damage being done to trees is of a localized nature. The increase in water level created new headlands which are actively eroding. Undercutting has progressed to the point where trees are falling into the lake (Figure 6).

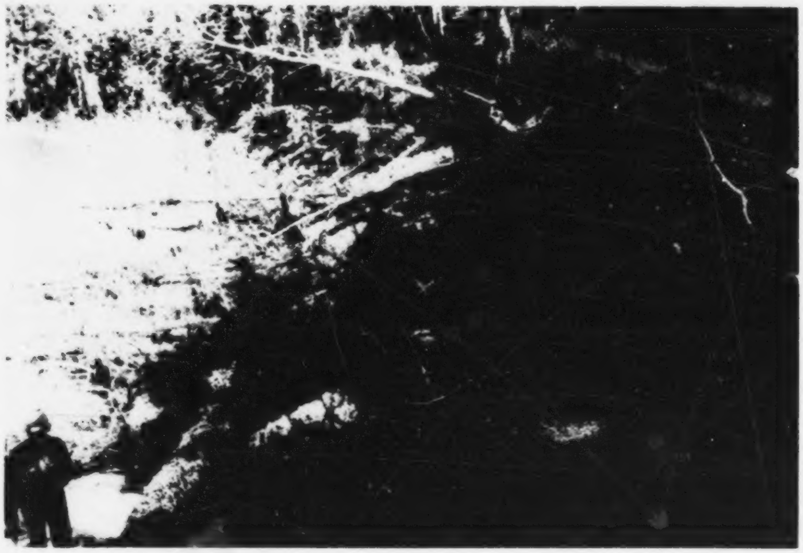

Figure 6. Result of active headland erosion, line 7, Sipiwesk Lake

The differential dying of species as a result of flooding was also noted. The willow, trembling aspen and balsam poplar dead line was always lower on the slope than the spruce dead line where spruce occured in combination with one or more of the hardwood species. In one instance willow was growing in what appeared to be a permanently flooded condition.

One white spruce tree was found near death, growing well into the dead zone at the start of line two. The growth rings of even this tree (Figure 7) show no signs of suppression.

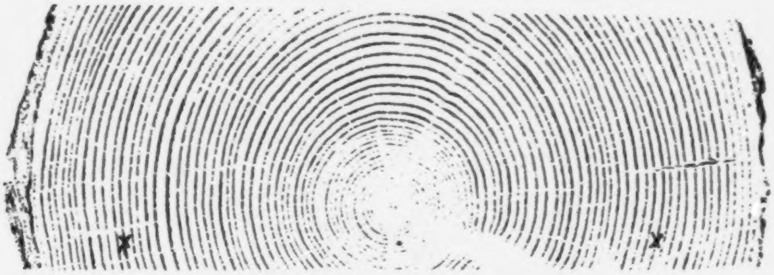

Figure 7. A section of a white spruce tree growing in flood killed material. Note the relatively uniform growth rings before and after flooding. Scale 1:1; X marks year of reservoir formation.

VII CONCLUSION

It has long been recognized that different species react differently to flooding (Kramer and Kozlowski, 1960; Gill, 1970) so the differential dying of species recorded in this study was expected. Further investigation into this phenomenon would no doubt prove useful to agencies who may wish to maintain a woody vegetation cover on land which is flooded with an intolderable frequency for the survival of spruce and pine. Considerable work along these lines has been done in Europe and is reported in Gill (1970).

The death of trees as a result of flooding is complex and usually caused by the interaction of several factors. Details of the physiological effects of flooding and mechanisms of tolerance in species can be found in Kramer and Kozlowski (1960) and Gill (1970). In their general review, Kramer and Kozlowski (1960) mentioned reduced stem growth as a result of flooding. Contrary to this Green (1947) found that the annual radial growth of seven bottom land hardwood tree species growing on the Upper Mississippi River was not affected by permanent flooding but when death came, it was sudden. In the same study flooding was not found to be detrimental to the radial growth of trees growing on the two foot contour above the reservoirs where samples were taken. Both of Green's points are in agreement with the findings here.

The general increase in increment noted at both study sites was probably due to an improvement in the general climate over the past few years as opposed to a possible irrigation effect from an improved soil moisture status. Line seven (Table 9) at Sipiwesk Lake started from a 15 foot bank (Figure 6) and the last sampled trees were growing approximately 40 feet above lake level. It is doubtful if the lake influence on the water table in these heavy textured soils would affect the trees growing there. This,coupled with the fact that the rooting habit of spruce is usually plate like (Figure 8) with very few roots penetrating the heavy textured mineral soil,would make this line as close to a control line as possible. The growth trends here were the same as for all other lines thus adding support to the improved climate hypothesis.

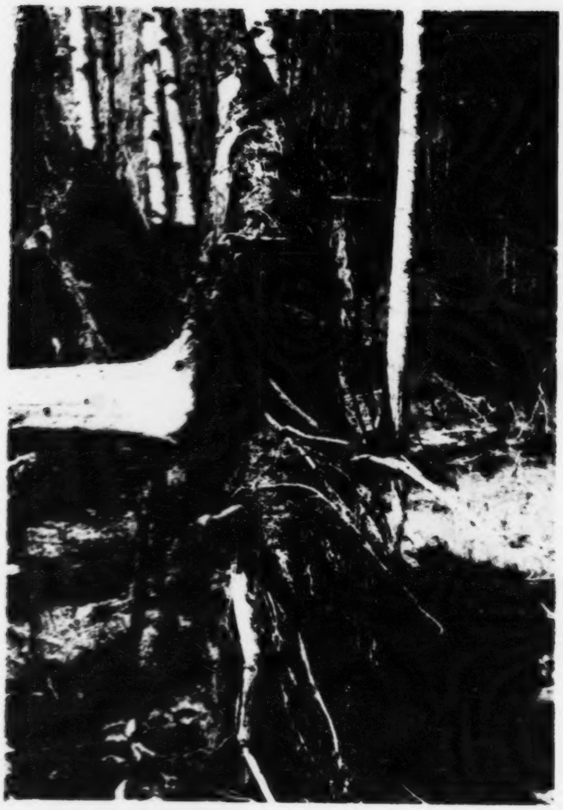

Figure 8. Plate like rooting habit of spruce, Sipiwesk Lake

TABLE 1: General forest description and radial growth comparisons for line one, Cross Lake

Main Stand Age: 25 - 60 years Height: 35 feet

Species Composition: 100% Jack Pine (jp) with some aspen along the shore.

Main Ground Cover: shrubs and herbs

Soil Material: stoney glacial till with a sandy loam texture

Comments: shore at time of sample was well below the dead line

Point	Distance from Dead line (feet)	Depth to Water Table (inches)	Slope (%)	Tree No.	Species	Height (feet)	Age (yrs)	Radial Increment		Comments
								Before Flooding (units of 1/10 inches)	After Flooding	
1	0	36<	6	1	jp	32	60	3.7	2.6	
				2	jp	22	26	3.2	4.1	
2	50	36<	10	1	jp	30	23	4.0	5.4	
				2	jp					
3	100	36<	3	1	jp	21	28	4.2	4.5	very thin soil
				2	jp					
4	275	36<	0	1	jp	30	51	2.6	2.4	very thin soil
				2	jp					
5				1	jp					
				2	jp					

TABLE 2: General forest description and radial growth comparisons for line two, Cross Lake

Main Stand Age: 28 years Height: 25 feet

Species Composition: 90% jack pine (jp), 10% aspen

Main Ground Cover: herbs and shrubs

Soil Material: stoney glacial till with a clay loam texture

Comments: aspen-willow dead line 33' down slope from the pine dead line, small piles of sand left from wave erosion of the till were found - the beginning of a new beach. Dead trees were beginning to fall down.

Point	Distance from Dead line (feet)	Depth to Water Table (inches)	Slope (%)	Tree No.	Species	Height (feet)	Age (yrs)	Radial Increment (units of 1/40 inches) Before Flooding	After Flooding	Comments
1	0	36<	2	1	jp	24	28	3.8	5.0	Living tree in Figure - 4 on dead line
				2	jp	20	27	2.8	4.6	
2	50	36<	0	1	jp	25	30	3.6	4.0	
				2	jp	25	28	2.9	4.3	
3	100	36<	0	1	jp	26	29	2.9	4.6	
				2	jp	27	28	3.1	4.7	
4	150	36<	10	1	jp	25	27	2.4	3.3	
				2	jp	25	28	2.9	3.7	
5	250	36<	3	1	jp	22	29	2.6	2.4	exposed bed-rock at this point
				2	jp	23	30	3.4	3.9	

TABLE 3: General forest description and radial growth comparisons for line one, Sipiwesk Lake

Main Stand Age: 65-75 years Height: 45-55 feet

Species Composition: 75% white spruce (WS), 25% aspen

Main Ground Cover: moss, herbs and shrubs

Soil Material: lacustrine clay

Comments: bank erosion was relatively inactive at the start of this line

Point	Distance from Dead line (feet)	Depth to Water Table (inches)	Slope (%)	Tree No.	Species	Height (feet)	Age (yrs)	Radial Increment Before Flooding (units of 1/40 inches)	Radial Increment After Flooding (units of 1/40 inches)	Comments
1	0	36<	25	1	ws	50	65	1.7	2.0	6' from shore
				2	ws	47	70	2.0	2.5	
2	50	36<	2	1	ws	50	73	1.3	2.4	
				2	ws	53	78	2.1	3.0	
3	100	36<	2	1	ws	52	77	1.2	2.5	
				2	ws	62	68	2.1	3.9	
4	150	36<	3	1	ws	50	65	2.4	2.4	
				2	wb	70	139	2.3	2.3	
5	250	36<	10	1	ws	72	175	0.7	1.0	
				2	ws	54	76	2.2	2.4	

TABLE 4: General forest description and radial growth comparisons for line two, Sipiwesk Lake

Main Stand Age: 70-80 years   Height: 40-50 feet

Species Composition: 100% black spruce (bs) with some aspen along the shore

Main Ground Cover: mosses and herbs

Soil Material: lacustrine plain

Comments: water visible 20 feet down slope from the spruce dead line, aspen were living 50 feet down slope from the spruce dead line.

Point	Distance from Dead line (feet)	Depth to Water Table (inches)	Slope (%)	Tree No.	Species	Height (feet)	Age (yrs)	Radial Increment Before Flooding (units of 1/40 inches)	Radial Increment After Flooding (units of 1/40 inches)	Comments
1	0	12	2	1	ws	40	69	1.8	2.5	
				2	bs	41	77	0.6	1.1	
2	50	10	2	1	bs	44	80	0.6	1.6	
				2	bs	40	76	0.9	1.4	
3	100	3	1	1	bs	45	66	o.6	1.0	
				2	bs	43	77	0.9	1.1	
4	150	14	2	1	bs	39	74	0.6	0.8	
				2	bs	38	80	0.5	0.9	
5	250	36<	6	1	bs	48	77	1.0	1.3	
				2	bs	50	76	0.6	1.0	

TABLE 5: General forest description and radial growth comparisons for line three, Sipiwesk Lake

Main Stand Age: 70-80 years Height: 35-45 feet

Species Composition: 100% black spruce (bs)

Main Ground Cover: mosses and herbs

Soil Material: lacustrine clay

Comments: dead line for balsam poplar was 50 feet below the deadline for spruce

Point	Distance from Dead line (feet)	Depth to Water Table (inches)	Slope (%)	Tree No.	Species	Height (feet)	Age (yrs)	Radial Increment Before Flooding (units of 1/40 inches)	 After Flooding	Comments
1	0	9	2	1	bs	30	68	0.7	1.0	
				2	bs	35	78	1.0	1.1	
2	50	19	3	1	bs	40	71	0.9	1.0	
				2	bs	38	72	1.0	1.1	
3	100	36<	1	1	bs	39	71	0.6	1.2	
				2	bs	45	74	0.6	1.3	
4	150	36<	1	1	bs	39	74	0.8	1.1	
				2	bs	38	78	0.7	0.9	
5	250	36<	2	1	bs	38	77	0.6	1.2	
				2	bs	40	79	0.7	1.0	

TABLE 6: General forest description and radial growth comparisons for line four, Sipiwesk Lake

Main Stand Age: 90-110 years Height: 45-60 feet

Species Composition: 100% black spruce (bs)

Main Ground Cover: feather moss

Soil Material: lacustrine clay

Comments: the dead line for spurce appeared to be above the high water mark.

Point	Distance from Dead line (feet)	Depth to Water Table (inches)	Slope (%)	Tree No.	Species	Height (feet)	Age (yrs)	Radial Increment Before Flooding (units of 1/40 inches)	Radial Increment After Flooding (units of 1/40 inches)	Comments
1	0	10	4	1	bs	48	98	0.7	0.8	
				2	bs	59	119	0.5	0.7	
2	50	18	2	1	bs	52	112	0.8	1.0	
				2	bs	51	106	0.9	0.9	
3	100	36<	1	1	bs	56	106	0.5	1.0	
				2	bs	55	104	0.6	0.9	
4	150	36<	5>	1	bs	50	95	1.1	1.3	
				2	bs	60	110	0.6	0.9	
5	250	36<	2	1	bs	44	84	1.2	1.4	
				2	bs	45	77	0.8	1.0	

TABLE 7: General forest description and radial growth comparisons for line five, Sipiwesk Lake

Main Stand Age: 100-130 years Height: 50-65 feet

Species Composition: 75% black spruce (bs), 20% white spruce (ws), 5% aspen

Main Ground Cover: feather moss and herbs

Soil Material: lacustrine clay

Comments:

Point	Distance from Dead line (feet)	Depth to Water Table (inches)	Slope (%)	Tree No.	Species	Height (feet)	Age (yrs)	Radial Increment Before Flooding (units of 1/40 inches)	 After Flooding (units of 1/40 inches)	Comments
1	0	7	4	1	bs	56	109	0.4	0.5	water table perched on Et horizon
				2	ws	62	128	0.7	0.5	
2	50	36	2	1	bs	56	105	0.5	0.6	
				2	bs	59	109	0.7	0.8	
3	100	8	2	1	bs	44	108	0.5	0.6	water table perched on Et horizon
				2	bs	50	99	0.9	1.1	
4	150	8	2	1	bs	49	105	0.6	0.9	water table perched on Et horizon
				2	bs	56	97	0.9	1.0	
5	250	8	1	1	bs	60	111	0.7	1.0	
				2	ws	62	104	0.9	1.0	

TABLE 8: General forest description and radial growth comparisons for line six, Sipiwesk Lake

Main Stand Age: 70-90 years Height: 35-50 feet

Species Composition: 100% black spruce (bs)

Main Ground Cover: feather moss and shrubs

Soil Material: lacustrine clay

Comments:

Point	Distance from Dead line (feet)	Depth to Water Table (inches)	Slope (%)	Tree No.	Species	Height (feet)	Age (yrs)	Radial Increment Before Flooding (units of 1/40 inches)	Radial Increment After Flooding (units of 1/40 inches)	Comments
1	0	36<	3	1	bs	42	85	0.8	1.4	
				2	bs	36	69	0.7	1.0	
2	50	36<	2	1	bs	44	73	0.7	1.2	
				2	bs	40	79	0.6	1.1	
3	100	36<	1	1	bs	44	73	0.6	1.1	
				2	bs	45	60	1.3	1.9	
4	150	36<	2	1	bs	51	77	1.3	1.5	
				2	bs	49	77	0.7	1.1	
5	250	36<	0	1	bs	48	76	0.6	1.0	
				2	bs	47	76	0.8	1.1	

TABLE 9: General forest description and radial growth comparisons for line seven, Sipiwesk Lake

Main Stand Age: 60-75 years Height: 40-45 feet

Species Composition: 90% black spruce (bs), 5% white spruce (ws), and 5% aspen

Main Ground Cover: feather moss and shrubs

Soil Material: lacustrine clay

Comments:

Point	Distance from Dead line (feet)	Depth to Water Table (inches)	Slope (%)	Tree No.	Species	Height (feet)	Age (yrs)	Radial Increment		Comments
								Before Flooding	After Flooding	
								(units of 1/40 inches)		
1	0	36 <	10	1	bs	45	63	1.2	1.6	high bank (15')
				2	bs	39	75	1.0	1.5	
2	50	36 <	11	1	ws	44	74	0.7	1.0	
				2	bs	45	74	1.0	1.2	
3	100	36 <	9	1	bs	42	71	0.6	1.2	
				2	bs	41	75	0.6	1.2	
4	150	36 <	11	1	bs	46	69	1.1	1.6	
				2	bs	42	68	1.0	1.2	
5	250	36 <	8	1	bs	40	72	1.2	1.4	
				2	bs	40	73	1.0	1.5	

TABLE 10: General forest description and radial growth comparisons for line eight, Sipiwesk Lake

Main Stand Age:

Species Composition: 95% black spruce (bs), 5% white spruce (ws), and aspen

Main Ground Cover: feather moss, herbs and shrubs

Soil Material: lacustrine clay

Comments: the white spruce was growing mainly along the shore.

Point	Distance from Dead line (feet)	Depth to Water Table (inches)	Slope (%)	Tree No.	Species	Height (feet)	Age (yrs)	Radial Increment Before Flooding (units of 1/40 inches)	Radial Increment After Flooding (units of 1/40 inches)	Comments
1	0	36<	2	1	ws	33	69	1.5	1.3	6' from shore - 2' bank
				2	ws	37	75	1.0	0.9	
2	50	36<	0	1	bs	48	73	0.6	1.1	
				2	bs	50	73	1.4	1.1	
3	100	36<	1	1	bs	39	71	1.1	1.4	
				2	bs	39	75	1.0	1.6	
4	150	36<	1	1	bs	38	72	0.6	1.2	
				2	bs	44	76	1.0	1.4	
5	250	36<	<5	1	bs	40	70	0.6	1.3	
				2	bs	39	70	0.7	1.1	

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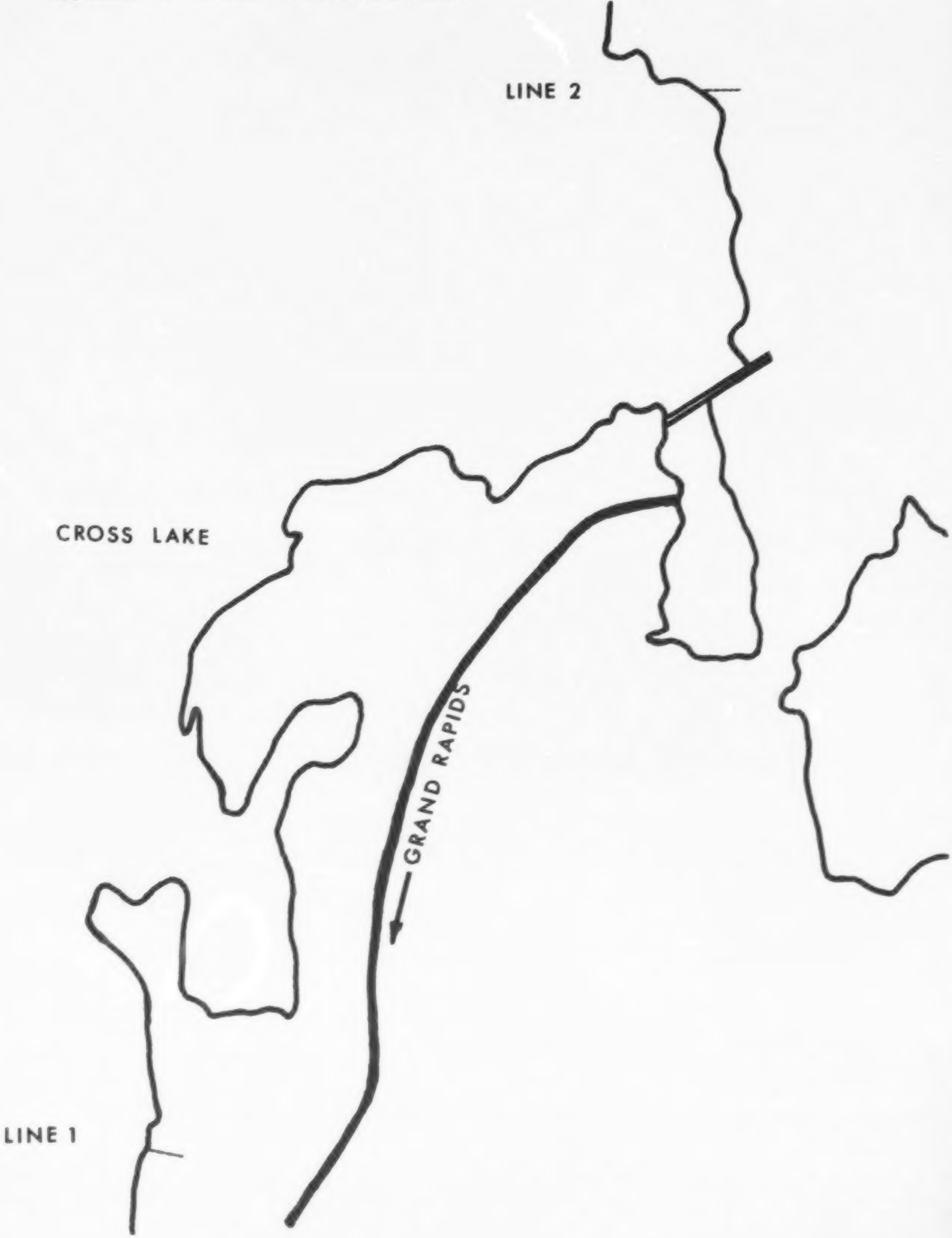
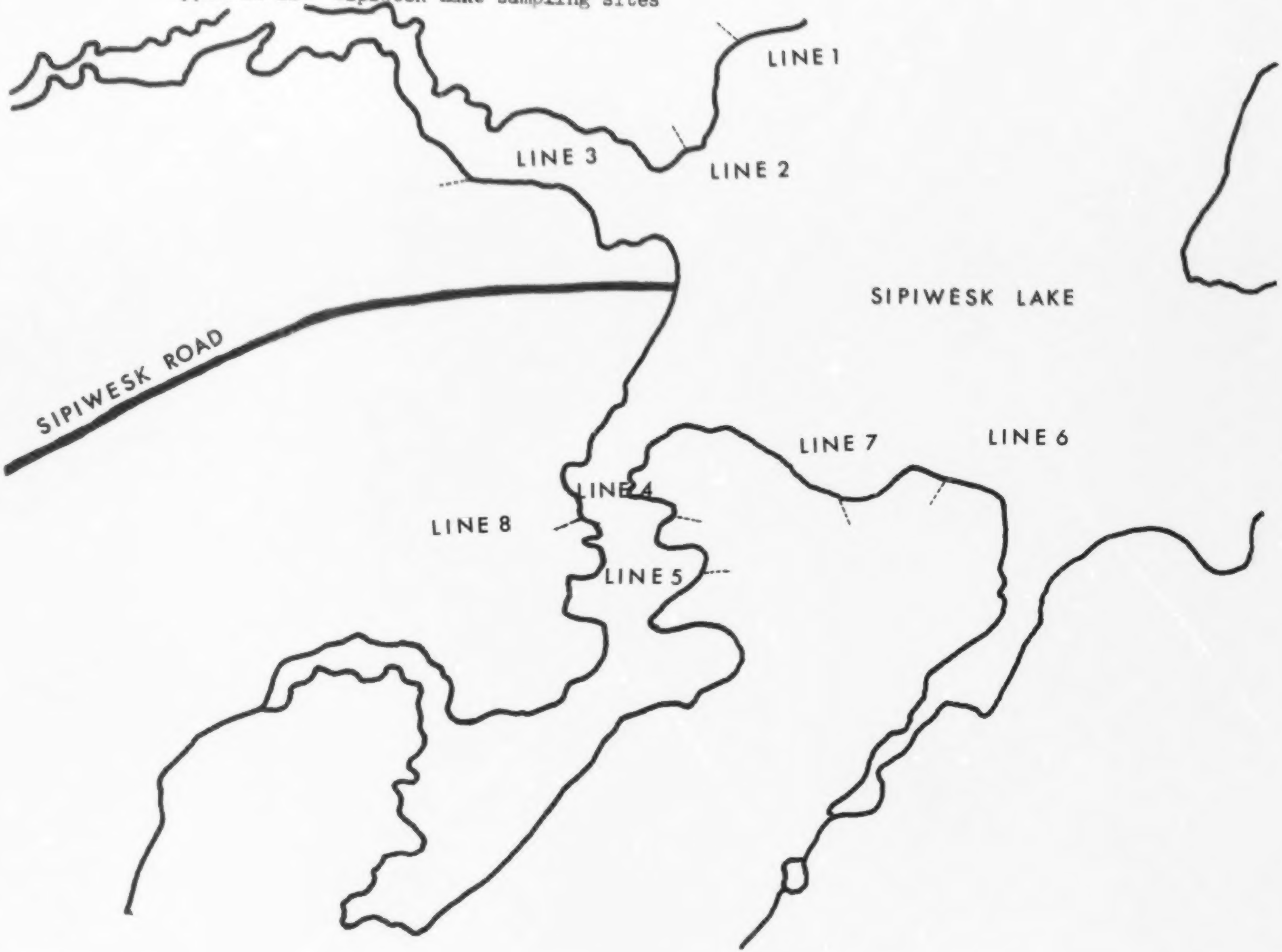
APPENDIX

Appendix 1: Cross Lake sampling sites


LINE 2
CROSS LAKE
GRAND RAPIDS
LINE 1

Appendix 11: Sipiwesk Lake sampling sites


LINE 1
LINE 2
LINE 3
SIPIWESK LAKE
SIPIWESK ROAD
LINE 7
LINE 6
LINE 4
LINE 8
LINE 5

APPENDIX 3 - G

WEST CHANNEL RESERVOIR CLEARING PROGRAM

WEST CHANNEL RESERVOIR CLEARING PROGRAM

by

D. DUNCAN
F. F. Slaney and Company Limited
Vancouver, British Columbia
October, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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- 3.8 Transportation 15

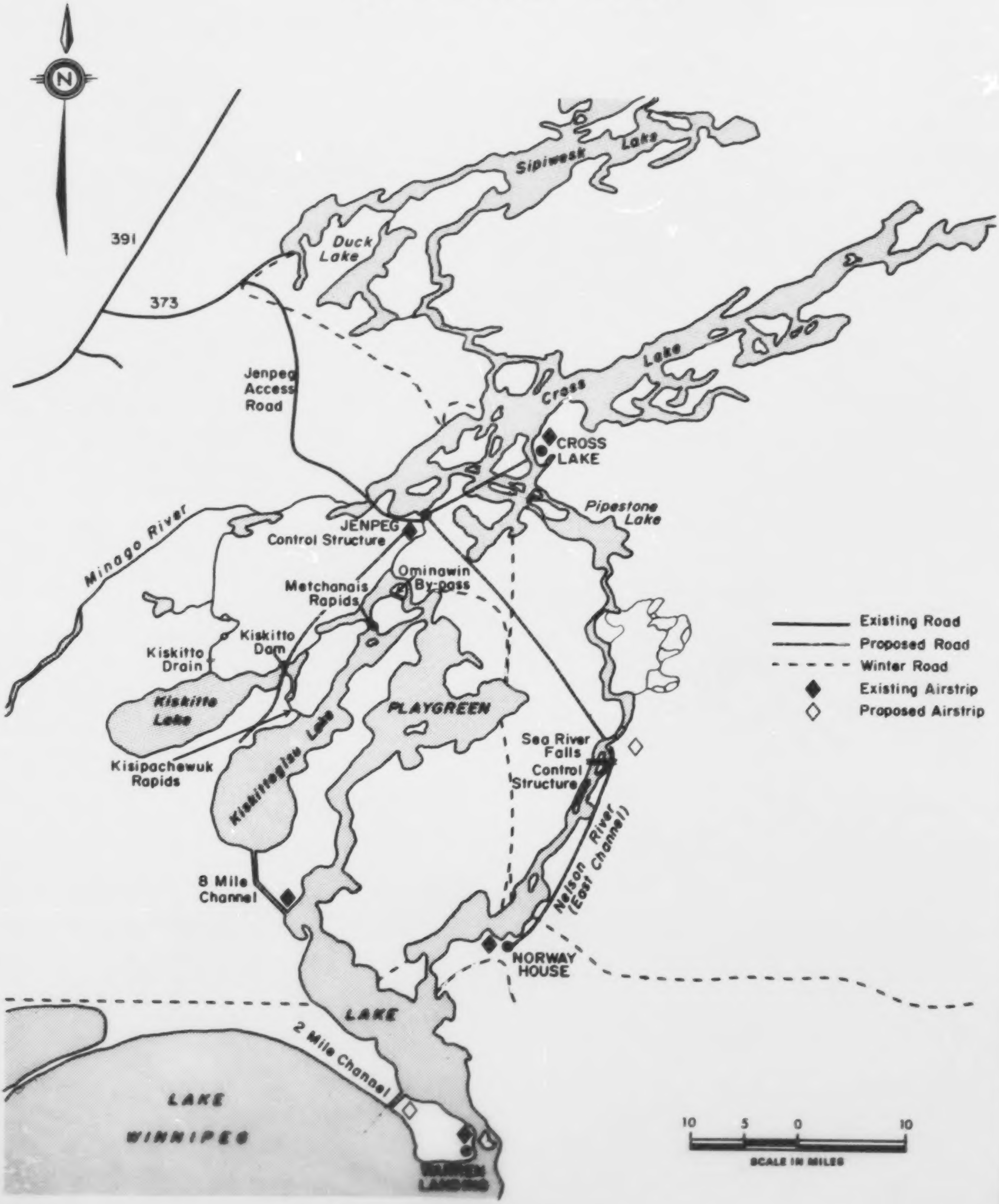
APPENDIX 101

APPENDIX 201

AREA MAPS

KEY MAP

OUTLET LAKES REGION


N
391
373
Duck Lake
Sipiwesk Lake
Cross Lake
CROSS LAKE
Pipestone Lake
Jenpeg Access Road
JENPEG Control Structure
Minago River
Ominawin By-pass
Metchanais Rapids
Kiskitto Dam
Kiskitto Drain
Kiskitto Lake
Kisipachewuk Rapids
Kiskittogisu Lake
PLAYGREEN
LAKE
Sea River Falls Control Structure
Nelson River (East Channel)
8 Mile Channel
NORWAY HOUSE
2 Mile Channel
LAKE WINNIPEG
WARREN LANDING
Existing Road
Proposed Road
Winter Road
Existing Airstrip
Proposed Airstrip
10
5
0
10
SCALE IN MILES

INTRODUCTION

The basic premise of the clearing program in the Jenpeg Forebay area was to clear and if possible salvage merchantable timber from the west channel area. Delineations of forest types to be cleared is often difficult to rationalize at this stage, and the patch pattern of clearing probably will appear even less logical when flooded.

The efficiency and workmanship of contractors and hydro supervisory staff is excellent. The cleared areas are exceptionally well groomed. The opportunity to salvage merchantable logs was rejected by most clearing contractors, and consequently most of the timber was piled for burning. Clearing contracts expire April 1, 1974.

The clearing progress should be re-assessed when current contracts have expired. Some adjustments to accommodate specific requirements of fishery, forestry, wildlife, recreation, economics or aesthetics should be anticipated. Emphasis should be placed on on-site deliberations with all parties concerned.

Post-flooding clearing requirements should be defined after the reservoir level has reached full pond and after activities in the area have evolved over a period of two or more years.

A report on Underwater Cutting Techniques has been prepared for Manitoba Hydro and provides supplementary data to this report.

Report prepared by D.H. Duncan, P. Ag.

PART 1

THE RESERVOIR SITE : OUTLET LAKES

1.1 THE RESERVOIR SITE

The reservoir site includes all land upstream from the Jenpeg dam site to an elevation of 715 feet. The 715-foot contour has not been fully established on the ground, and the total extent of the proposed reservoir site is not defined. The reservoir site includes parts of Forest Management Units 82 and 83 under lease from the Provincial Government by two firms: Churchill Forest Industries (Manitoba) Limited, 12,628; and Marine Transport, 11,324 acres.[1]

1.1.1 The Forest

Detailed forest cover data is available for about 24,000 acres (about 37 square miles) of the proposed reservoir site. The area mapped and surveyed is within the boreal forest region of the Northern Clay Belt of Manitoba. Clay depths over bedrock are from a few inches to over 10 feet. Rock outcroppings are infrequent. The lands within the proposed reservoir site are characteristically flat and wet.[1]

1.1.1.1 The Classification of Surveyed Forest Lands

Surveyed lands are west of Principal Meridian and include Township 63 and 64, Ranges 4 and 5; Township 61, Ranges 6 and 7; Township 62, Ranges 4, 5 and 6.

---

[1] Forest Inventory Report for the "Jenpeg" project, Department of Mines, Resources and Environmental Management, Province of Manitoba, 1972.

Forest Type Classification	Area (Acres)
Mature Softwood (Conifers)	8,800
Mature Hardwood (Deciduous Broadleaf)	2,600
Immature Stands	1,800
Total Productive Forest Land	13,200
Non-Productive Forest Land	9,800
Non-Forested Land	1,000
Total Non-Productive Forest Land	10,800
GRAND TOTAL	24,000

Note: This inventory includes all lands below elevation 715 feet within the townships indicated. The extent of flooding outside of these units is not known. The areas outside were excluded from this inventory on the basis that the forests are not under lease to forestry concerns.

1.1.1.2 Net Merchantable Volume of Timber Within Operative Stands

Operative stands include forest types where the combined net volume of pine, spruce and balsam stems over four inches d.b.h. was 800 cubic feet per acre or greater.

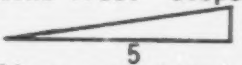
Net merchantable volume is the volume of all species with diameters (breast height) of 3.6 inches and larger, after the respective cull factors by species have been deducted.

Species	Net Volume (Cubic Feet)
Softwood (Spruce, Pine, Balsam, Birch)	9,700,000
Hardwood (Poplar, Birch)	1,800,000
	11,500,000

Note: The net volume shown excludes mature timber growing in deciduous stands and timber in mixed stands where the softwood component is less than 800 cubic feet per acre.

Dominant woody shrubs associated with the commercial species of trees include willow, alder and birch.

1.2 SHORELINE CHARACTERISTICS

Basic characteristics of the shorelines in the Outlet Lake region were obtained from "Physical Impact Study, Interim Report 1972", prepared for the Study Board (See Appendix 101). Treed muskeg and willow characterize the area. The land is generally flat and stone free. Slopes of existing shorelines range from about 1:5  1 for bedrock controlled slopes; 1:10 for shorelines associated with muskeg or coarse sediments. Poorly defined, almost flat shorelines are associated with fine sediments and floating fens.

PART 2

THE ACTIVE CLEARING PROGRAM

2.1 DESIGN OF CLEARING PROGRAM : JENPEG FOREBAY

General specifications for clearing the Jenpeg Forebay were drawn up by the Department of Mines, Resources and Environmental Management and presented to Manitoba Hydro on July 20, 1972. A copy of the directive signed by W. George Bowen is included as Appendix 201.

Clearing guidelines were focused on the stands of merchantable timber in the west channel of the Nelson River. The recreational aspects of the clearing program were apparently a lesser consideration.

The preflooding clearing program outlined in the guidelines represents a preliminary phase. Additional clearing up to $1,000,000 is to be held in reserve until after flooding so that funds are available for clearing specific areas of concern.

2.2 THE CLEARING PROGRAM : JENPEG FOREBAY

Manitoba Hydro has designed and instigated a clearing program that follows the prescribed guidelines. The contract specifications, the selection of contractors and the performance of both hydro field crews and the clearing contractor operators is excellent. Forest lands have been cleared to a high standard and with minimal disturbance of the root mat. Contract prices were reasonable and ranged from $219 to $636 per acre. The average cost per acre for complete disposal of the forest cover was about $400 per acre for some 12,000 acres of forest land. The cost of shearing alone would be about $100 per acre. Five private contractors and one government-sponsored clearing concern for training crews were awarded contracts. Completion date of contracts is April 1, 1974. The total cost of the clearing operation for the Jenpeg Forebay area is in the order of $5,000,000.

Clearing contractors are equipped with relatively large machines and attuned psychologically to remove forest cover by the most economical means possible. Loggers are equipped with relatively small machines and attuned psychologically to harvest merchantable trees with minimum disturbance to remaining forest cover. Rarely are loggers and slashing crews compatible. Where the salvage of timber is economically feasible, road building and logging should preceed clearing operations and separate contracts should be let.

The clearing contractors, awarded contracts to dispose of forest cover on a unit price per acre basis, burned the merchantable timber along with the debris. Established forest operators usually have cutting programs designed decades ahead of their operations and major shifts in development plans require several years preplanning so that access roads, special equipment and often marketing can be modified to suit the particular stand and logging conditions of the site.

In the Jenpeg Forebay area the net effect of the requirement to clear stands of merchantable timber and leave stands of nonmerchantable timber is not particularly desirable. Boat access in the reservoir would be hampered by forest stands left in large openings, and conversely isolated clearings situated behind massive stands of non-merchantable material afford no particular aesthetic or physical enhancement of the site.

The type line or boundary separating a timber stand with over 800 cubic feet per acre of softwood and a forest stand with less than 800 cubic feet is measurable by intensive sampling but is not visually apparent to an observer in the field. The resultant random pattern of open patches and clumps of trees appears illogical to most of the field crews. The exact boundaries of cutting blocks are being modified in the field and will not be final until April, 1974.

2.3 LOG SALVAGE

Some contractors have attempted to salvage areas of the better timber. Tree length logs were being decked over the winter for transport south by water during the summer. The fluctuating lumber prices, hazards of fungus and insect infestation and potential losses by storm en route are risks that most operators who sell logs on the open market are not willing to accept for the minimal rewards which may accrue.

Boomsticks will be premium products immediately after flooding. This requirement should be scheduled for salvage during the winter preceeding flooding.

2.4 CLEARING UNSURVEYED AREAS

Clearing of the unsurveyed portions of the reservoir site was not considered in the original plan. The 715-foot elevation contour has not been plotted on detailed maps and consequently the full extent of the reservoir is not known within an acceptable accuracy for forestry or clearing purposes.

Lands to be flooded other than the west channel to elevation 715 feet would include extensive areas of marsh and treed muskeg.

The flat wetlands characteristic of most of the reservoir environs support riparian vegetation that is tolerant to flooding. Most of the taller deciduous vegetation within the drawdown zone will survive unless the plant is completely inundated. Riparian vegetation that has been sheared off or crushed would probably not survive even shallow flooding.

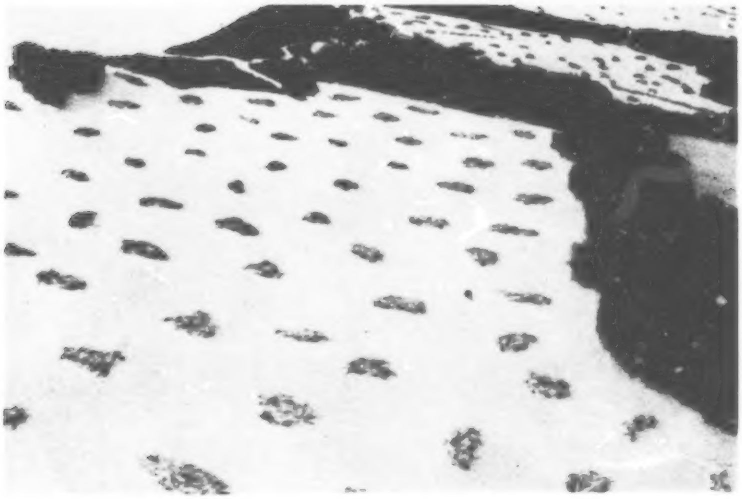
The coniferous species are less tolerant of flooding and most would die over a period of two or three years. Selective clearing of coniferous species is practical in certain forest types and is recommended for small areas where aesthetic consideration is significant and where the indiscriminate clearing of browse species may not be to the best advantage of wildlife populations, particularly during the transition period following initial inundation. Rocky or steep slopes would be more difficult to clear after flooding than the flatlands. Broken terrain may require special preflooding treatment.

RESERVOIR CLEARING: OUTLET LAKES

JENPEG FOREBAY

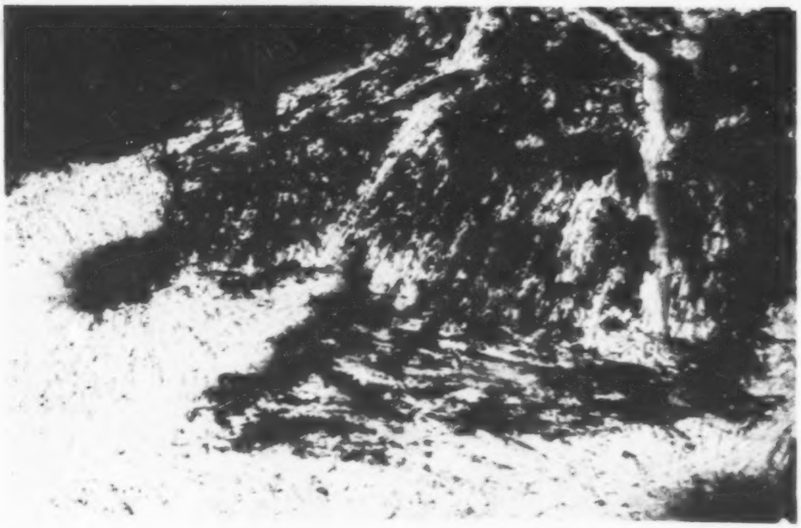
March 5, 1973. Some 12,000 acres (10,000 acres + 15%) are being cleared by six contractors. Clearing was about 60% completed at date of inspection. Work was progressing at the rate of about 500 acres per week.

1973. Clearing operators employed about 110 men to operate some 40 crawler tractors. Contract prices for complete disposal ranged from $219 to $636 per acre.



The clearing program was designed with the original intent of salvaging merchantable timber. Non-merchantable timber is being left, hence the patchy effect of clearing.

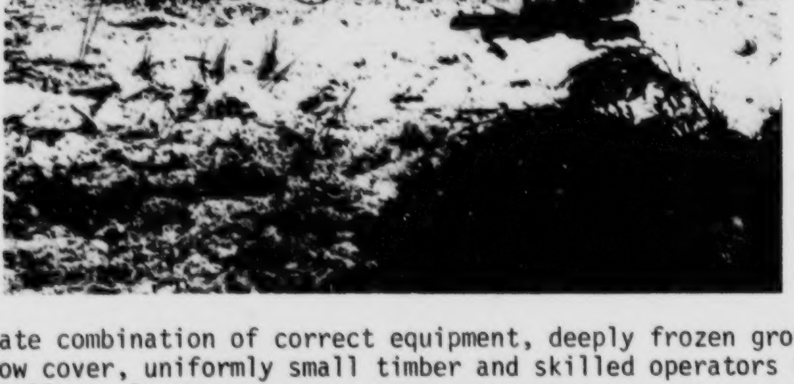
Odd clumps of non-merchantable timber are spotted throughout the cleared areas. Hydro field crews have complied with the guidelines. Understandably the hydro survey crews in the field were somewhat bewildered by the logic of what is to be cleared and what is to be left. On-site adjustments of lands to be cleared were limited to 15 percent.



Bulldozers with "V" cutters are remarkably efficient in shearing forest cover during frozen winter conditions. Each cutting unit was supported by about three piling units.

Piling operations should closely follow the felling. Burning may be delayed until favourable weather. Continuous cutting, piling and burning is usually the most efficient system. Only one of the six contractors consistently burned piles as work progressed. The remaining contractors left burning for fall.

Trees are sheared cleanly at the root collar. Piles are clean and well made for burning. Clearing contractors are forced because of capital costs and general shortages of skilled men to use massive equipment and keep the units operating continuously. An understanding of the capabilities and inclination of efficient clearing contractors is an essential component of designing a practical clearing program.



A fortunate combination of correct equipment, deeply frozen ground, light snow cover, uniformly small timber and skilled operators result in an excellent cleanup.

The cutting pattern should be re-assessed in the fall of 1973 and further clean-up of non-merchantable material may be warranted where recreational or transportation enhancement is perceived. Current clearing contracts expire on April 1, 1974.

Many patches of willow are being left within the reservoir site. In certain areas these shrubs would become the bane of sports fishermen with trolling tackle or commercial fishermen with net sets.

Many timber stands left on small islands are stark and unstable.

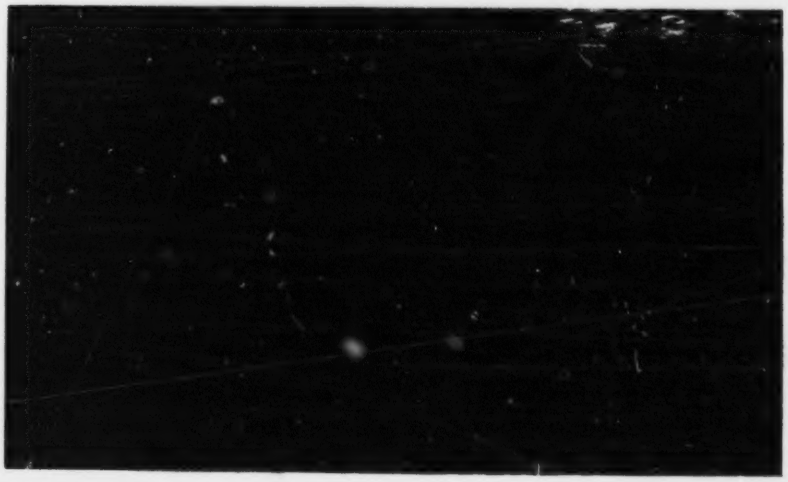
Blowdown will be heavy on these exposed faces.

Provision to cleanup fringes after flooding should be considered.

Isolated pockets of high quality timber occur throughout the reservoir site. The economic feasibility of salvaging this material is slight. A program to set aside the best of the timber for boomsticks would be worthwhile.

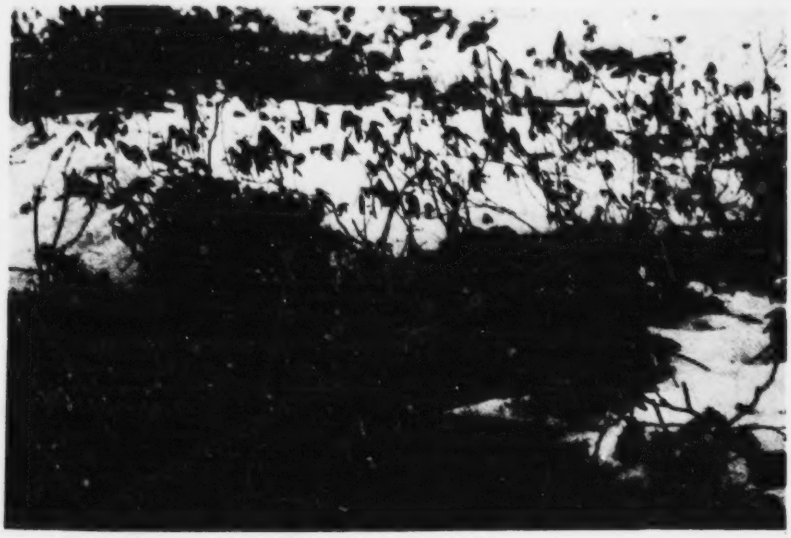
Tree length merchantable logs being decked by a clearing contractor. The operator has a substantial investment in recovering these logs and is accepting a high risk that the material will reach a conversion plant and be sold at a profit. Most contractors have calculated that a greater profit is obtained by burning this material with the general forest cover. The contractor makes better use of his capital and skilled labour by completing the project in a single operation and moving on to the next clearing contract.

July, 1973. Forebay of Whitesands Dam. Reindeer River, Saskatchewan. Deep alluvial deposits on steep slopes are susceptible to slumping for decades after flooding. The slope will stabilize at about 1:20.

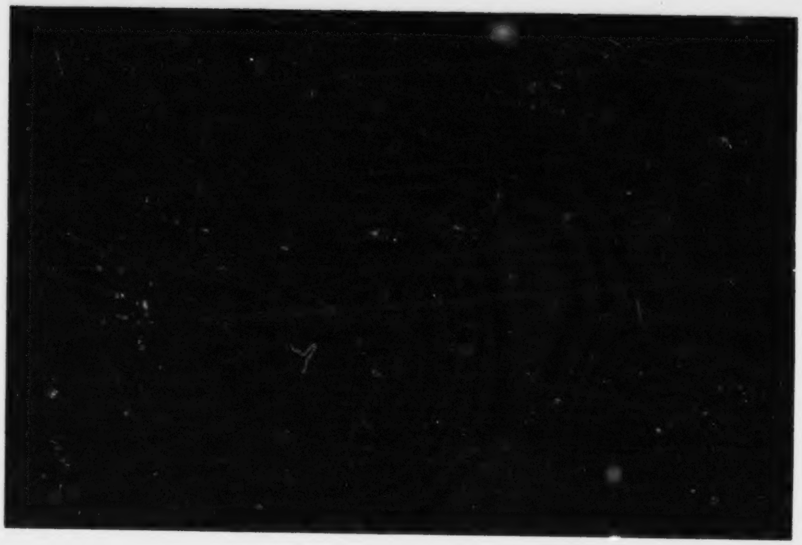


July, 1973. Churchill River, Saskatchewan. The reservoir behind Island Falls Dam is generally clear of debris. This floatage was one of the larger masses observed. Disposal of this material would be a simple operation utilizing a 1½ yard crane with a 60 foot straight boom and a log grapple. The floatage could be piled onto a continuously burning fire.

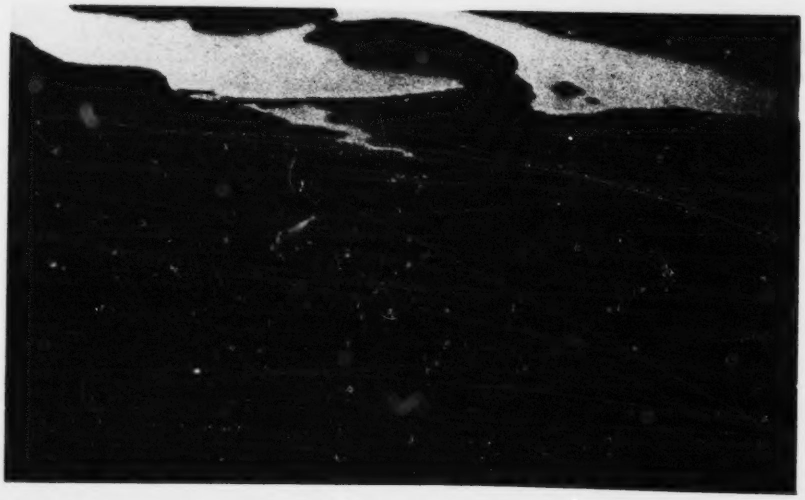
The "V" cutters have sheared this stand at a fraction of the cost of hand felling. Poor log prices, risk of losses, lack of manpower and the need for specialized equipment combine to discourage the salvaging of merchantable wood.



Low stumps combined with a virtually undisturbed ground cover will provide a firm mat to resist forces of erosion after inundation. Except in wave action zones where beach slopes are greater than 1:15 the inundated lands will remain stable and intact.

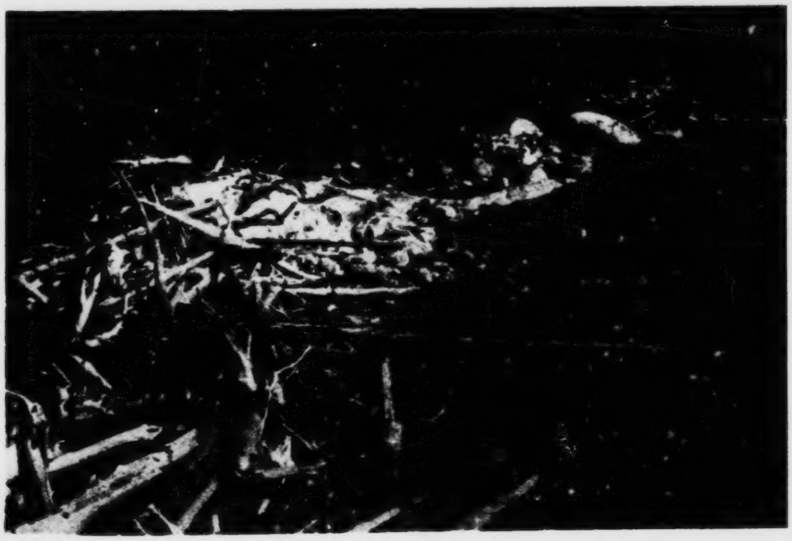


July, 1973. Reindeer Lake near Southend. Note that natural processes have broken off most trees at water level or slightly lower and that riparian vegetation has re-established along the shore. The level of water in Reindeer Lake has been raised a total of about 11 feet in two stages. The flood-killed timber is in evidence but is not particularly obtrusive.

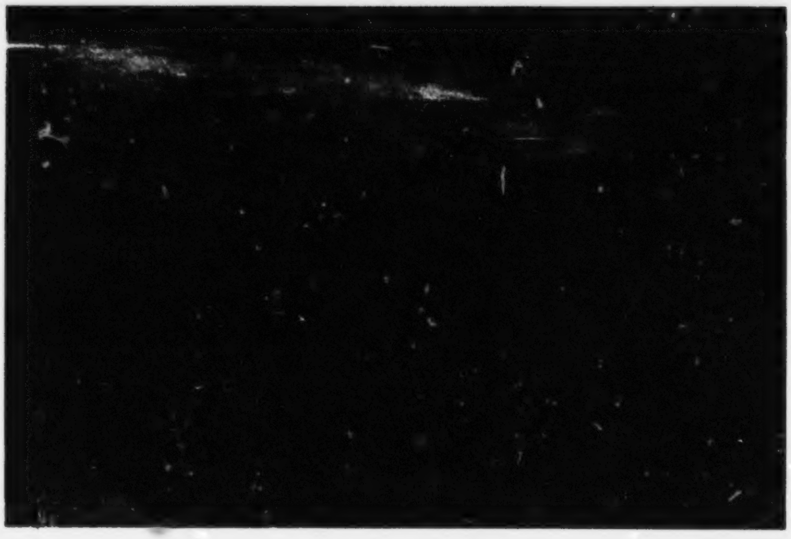


July, 1973. Churchill River System, Saskatchewan. Island Falls Reservoir System. The swampy draw in the centre of the photograph is characteristic of much of the area to be inundated at the Outlet Lakes area. Note that the flooded conifers died but the willow and other riparian vegetation thrived under the new regime of water levels.

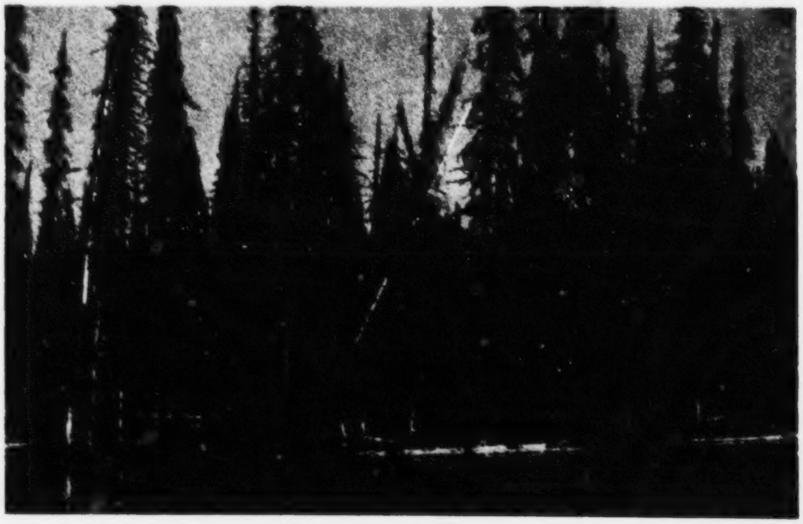
1972. Alcan Reservoir, B.C. Shorelines are often difficult areas to clear after flooding. The areas are usually inaccessible to machines during the summer and most of the material at the water's edge is frozen in over the winter. Clearing flat shorelines before flooding involves extensive and accurate mapping and field surveying.



July, 1973. Reindeer Lake. Natural processes are actively developing the shoreline at Reindeer Lake. Most of the debris has been driven ashore and the lake proper is free of floatage. The forest edge is surprisingly unstable on this rocky base. Aesthetically the bleached driftwood is not particularly obtrusive but the sight of dead trees standing in water is always an affront to one's aesthetic senses.

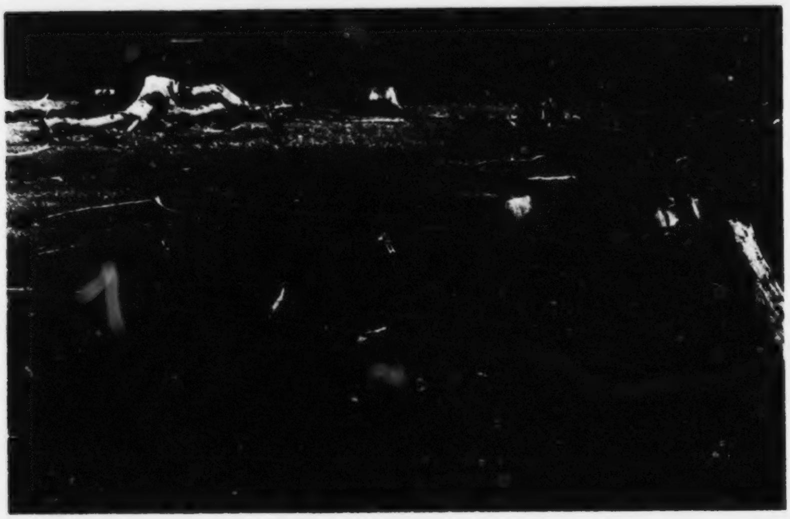


1972. Alcan Reservoir, B.C. Some 20 years of ice, wind, wave and biological activity have had little effect on some stands. In other sites the flood-killed cover has all but disappeared.

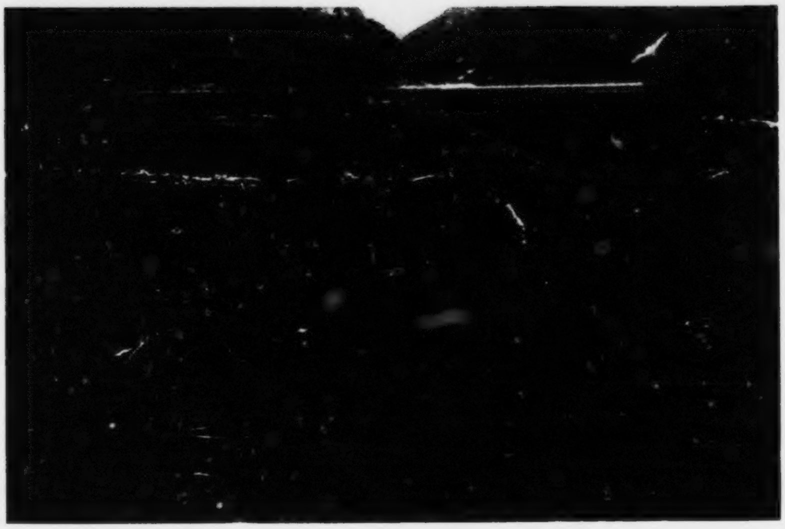


1972. Alcan Reservoir, B.C. Flooded about 1953. Access to shore is a major concern where forests are heavy and continuous.

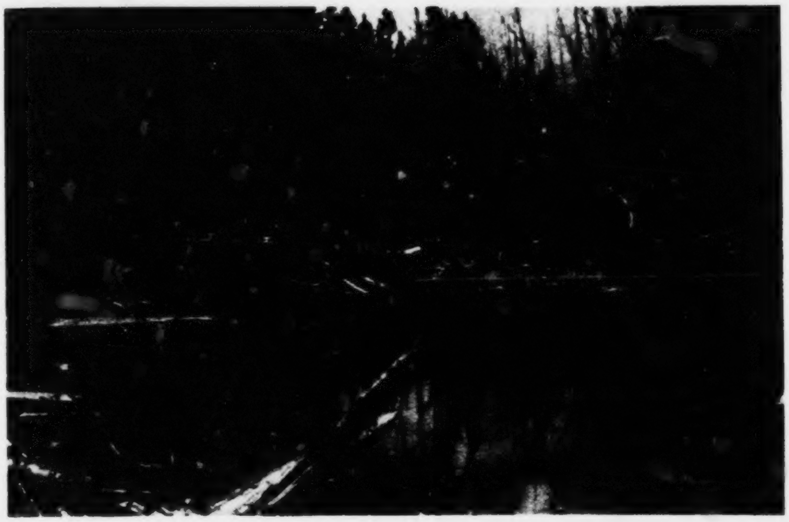
1973. Ross Reservoir, Skagit Valley. Flooded about 1950. Exposed slopes within wave action zones will degrade over time regardless of root mat. This slope is exposed to wave action about four months a year.



1973. Ross Reservoir, Skagit Valley. Flatter slopes adjacent to the degrading shoreline above are accumulating material.



1972. Skagit Valley. Flooded about 1950. The flat shoreline exposed to the longest reach is remarkably stable. Silts have not moved from the surface. Aquatic and semi-aquatic vegetation thrive. Flooded slopes less than 1:20 remain stable.



1972. Skagit Valley. Flooded about 1950. Flood-killed deciduous timber in the upper drawdown zone. Note the soil stabilizing growth of grasses and semi-aquatic plants are well established on flat sites.

1973. U.B.C. Forest, Haney, B.C. New, effective and reliable machines are being developed to harvest trees. Such units are easily mounted on barges or amphibious carriers for work on flooded merchantable stands. Other techniques for treating flooded timber are outlined in a report entitled "Underwater Cutting Techniques for Flooded Timber Stands" prepared for Manitoba Hydro.

1972. Alcan Reservoir, B.C. Salvage of 20-year old flood-killed timber is a reality. The material is used for lumber and chips.

PART 3

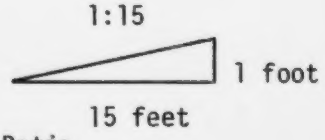
GENERAL CLEARING GUIDELINES : OUTLET LAKES AREA

3.1 SHORELINE EROSION OF RESERVOIR

The regression of the shoreline by water and ice action is a function of several elements:

- Regime of water levels
- Wave influence zone
- Ice movements
- Slope of shoreline
- Nature of material of shoreline
- Velocity, direction, duration and period of wind
- Length of reach fronting beach
- Type of forest cover flooded
- Extent and permanence of re-deposited material
- Presence of ice in the soil

The slope and nature of shoreline material are the ultimate controls on shoreline development. Other elements primarily affect the rate of development. The long term beach slope for various materials has been derived from stuides by PFRA and the U.S. Corps of Engineers.



Material	Beach Slope Ratio
Cobble 6" to 3" diameter	From: 1:5 to 1:9
Gravel less than 3" dia.	1:6 to 1:11
Sand Medium	1:15 to 1:20
Fine sands and silts	Becoming flat

The steeper slope is the projection for sheltered areas and the flatter slope is the projection for exposed beaches.

The extensive areas of generally flat shoreline will be relatively stable and may not reach an equilibrium during the life of the project because:

1. Reservoir drawdown and filling regimes spread the wave influence zone over a wide band and consequently the rate of shoreline development is retarded.

2. The dense root mat is mostly intact and in most areas aquatic plants, bush, trees and driftwood will buffer wave action.

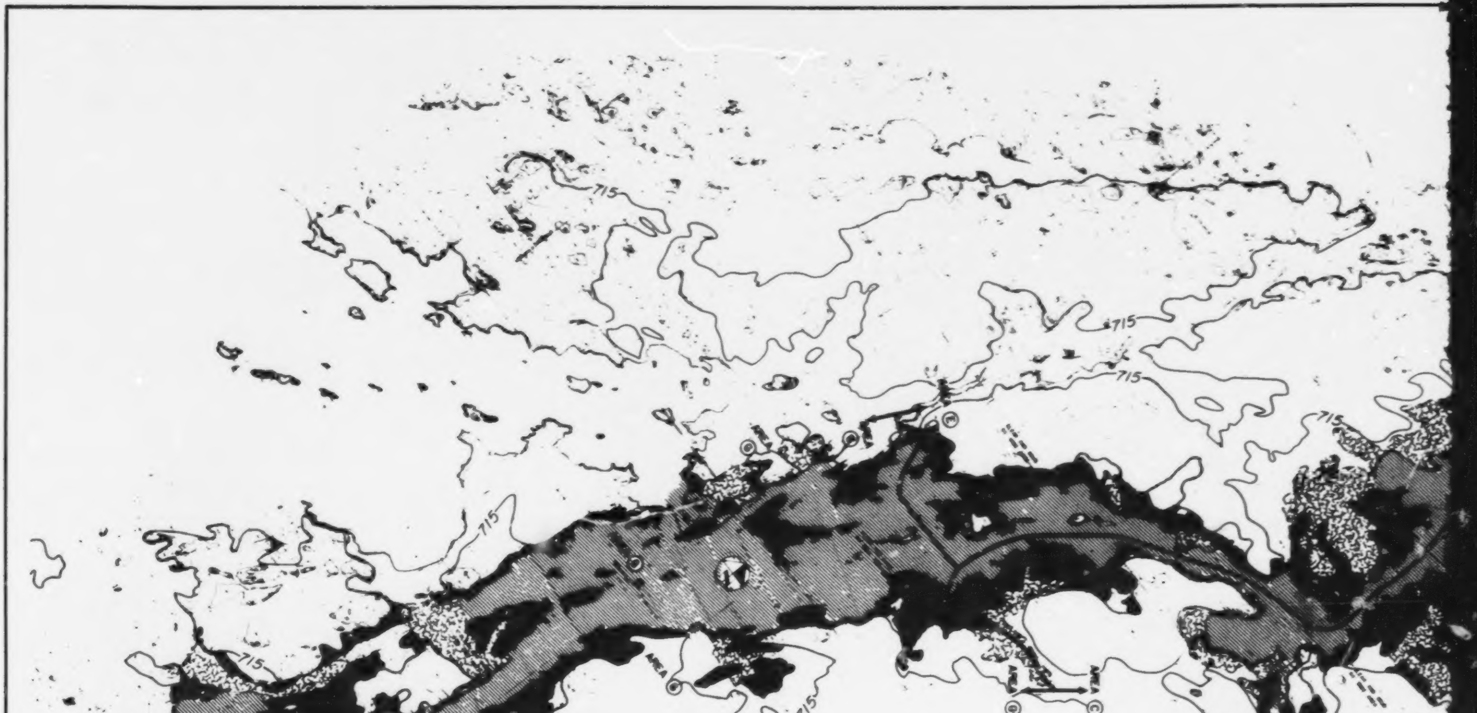
3. The land is flat and effects of gravity translocating soil particles is minimal.

Postponing the clearing of protective brush cover from flooded shallows until a mat of aquatic vegetation become established would help to reduce or eliminate disturbance from wave action and subsequent erosion of the shoreline.

The use of windrows or piles of debris in shallow water to dissipate wave action and stabilize alluvial deposits may be practical where some clearing is required for access. The probable area of peat lands and forest root mat that may float is difficult to ascertain. Such lands would float whether or not the surface cover was removed.

3.2 FISHERIES

The clearing of forest cover for sports fishery should be assessed on the basis of accessibility, aesthetic consideration, fishing season, campsite locations and the type of fishery projected.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AREA

FOREBAY CLEARING CONTRACT : JENPEG PROJECT

Contract Area	Approximate Area (Acres)
A & B	4,200
C	1,820
D	537
E	2,600
F	1,100
G	2,389
TOTAL	12,646

Note: Within t
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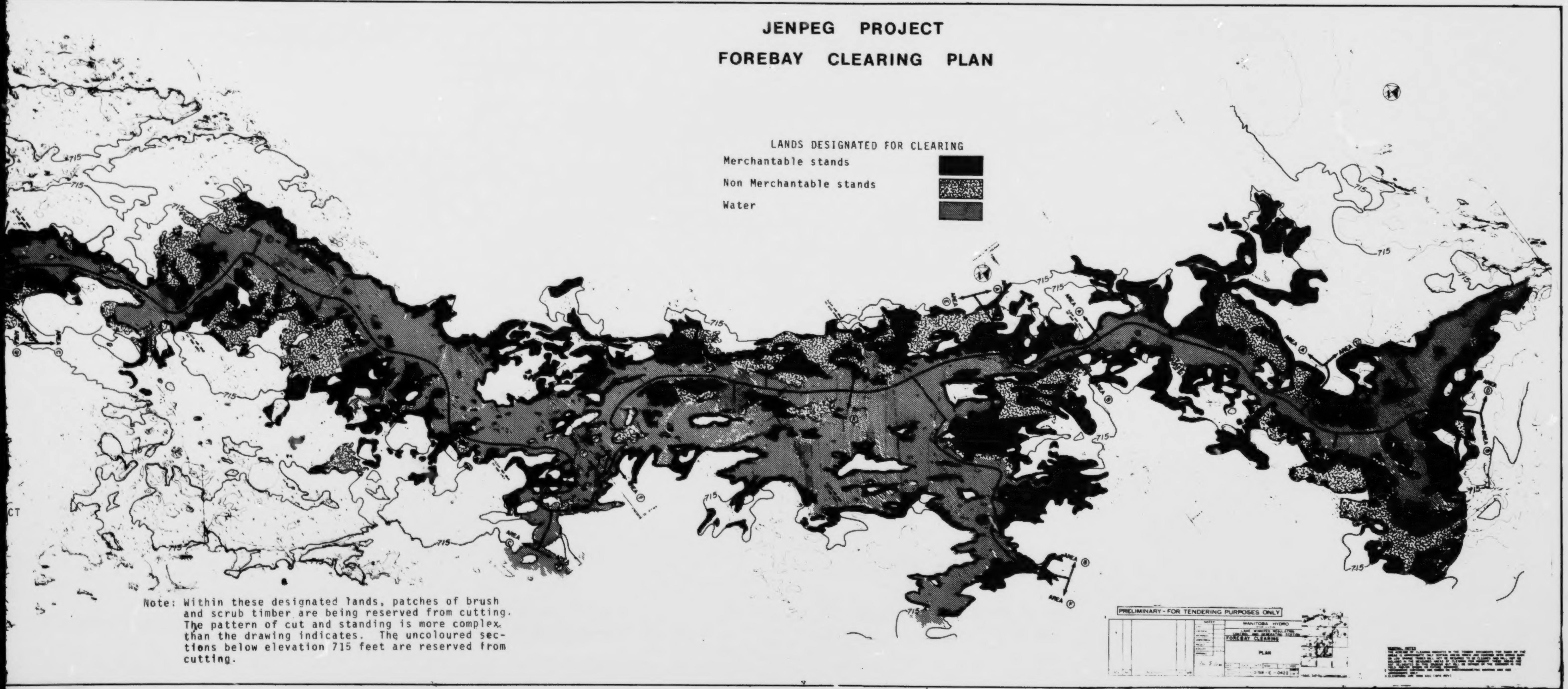
tions be
cutting.

JENPEG PROJECT
FOREBAY CLEARING PLAN



LANDS DESIGNATED FOR CLEARING

Merchantable stands	■
Non Merchantable stands	▨
Water	▩

Note: Within these designated lands, patches of brush and scrub timber are being reserved from cutting. The pattern of cut and standing is more complex than the drawing indicates. The uncoloured sections below elevation 715 feet are reserved from cutting.

715
AREA
AREA Ⓐ
AREA Ⓑ
AREA Ⓒ
AREA Ⓔ
AREA Ⓕ
PRELIMINARY - FOR TENDERING PURPOSES ONLY
NOTES
MANITOBA HYDRO
LAKE WINNIPEG REGULATION
CONTROL AND GENERATING STATION
FOREBAY CLEARING
PLAN
3198 - E - 0422
GENERAL NOTES

Legend Format

Region District Unit
0.0 AA 00
AA - 00
System

Legend

Land Region (__________)

Code	Name	Description
0	Arctic	Forest tundra; continuous permafrost
1	Arctic-Boreal	Subarctic forest; widespread permafrost
3	Boreal-Arctic	Northern boreal forest; discontinuous permafrost
3.1	Boreal, moist subhumid	Southern boreal forest; localized permafrost

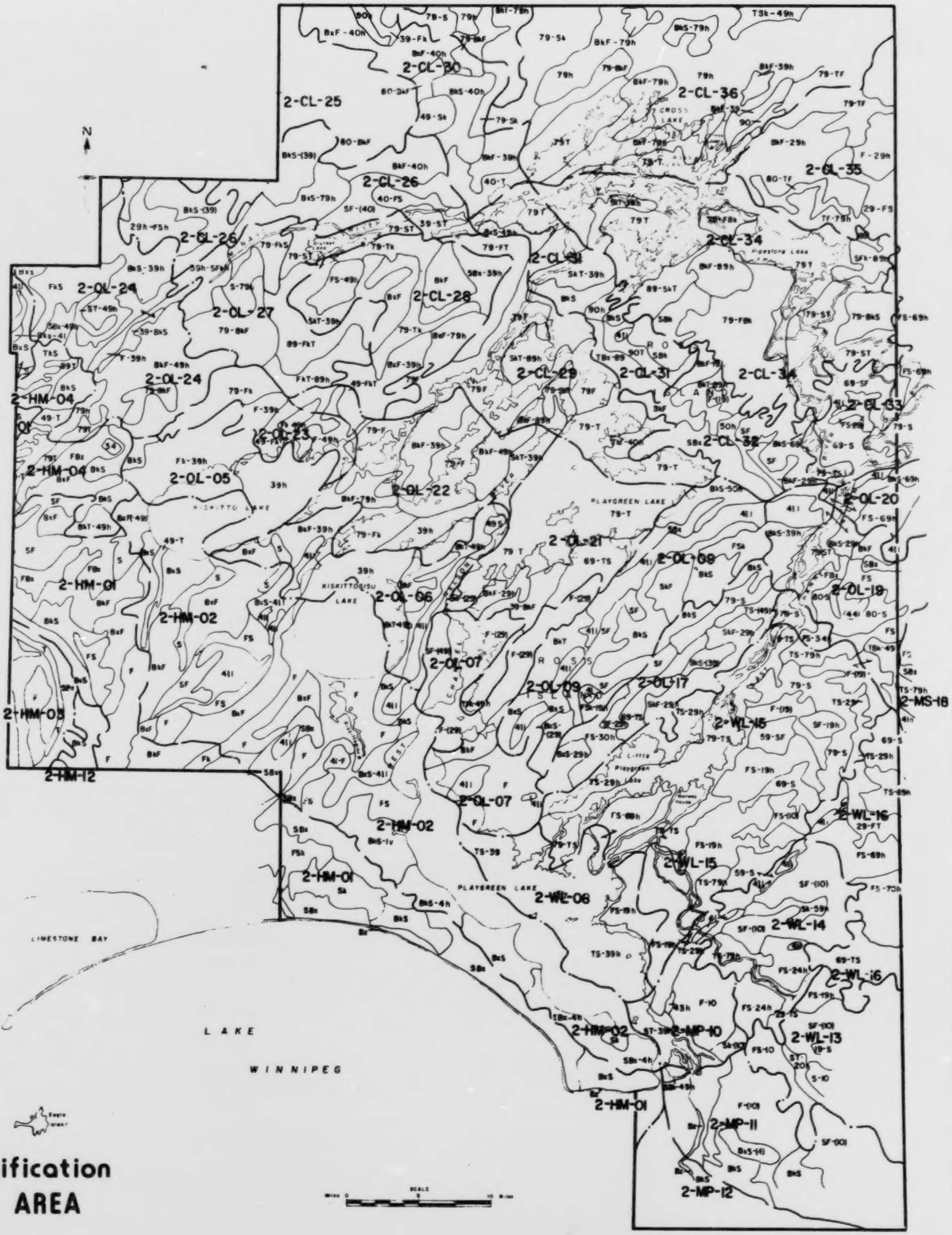
Land District (______ . ______ .)

Code	Name	Topography	Dominant Surface Materials	Geological Structure
HM	Hargrave	Nearly level	Org./Lac; Glacio-fluvial Lac./Till	Limestone
OL	Outlet Lakes	Gently undulating	Org./Lac; Lac./R; Glacio-fluvial	Igneous
CL	Cross Lake	Und. to gently rolling	Lac./R; Till; Org./Lac.	Igneous & Metamorphic
ML	Molson Lake	Gently rolling	Lac./R; Till	Igneous & Metamorphic
WL	Wabisi Lake	Und. to gently rolling	Org./Lac; Lac./R; Glacio-fluvial	Igneous
MP	Montreal Point	Nearly level	Org./Lac; Beach/Till	Igneous

Landscape Unit (______ ______)

Code	Slope Pattern	Surface Materials	Shoreline Configuration	Dominant Shore Materials
01	Very weakly broken	Organic/Lac./Till	Regular	Clay Till
02	Very weakly broken	Organic/Lac./Till; Glacio-fluvial	Regular	Organic; Clay Till
03	Very weakly broken	Org./Lac./Till; Beach/Till	--*	--
04	Very weakly to weakly broken	Org./Lac; Lac.	Somewhat irregular	Laminated Lac.
05	Very weakly broken	Org./Lac; Lac./Rock	Somewhat irregular	Bedrock; Lam. Lac.
06	Weakly broken	Org./Lac; Glacio-fluvial; Lac./R	Somewhat irregular	Organic; BR.
07	Very weakly to weakly broken	Org./Lac; Glacio-fluvial; Lac./R.	Somewhat irregular	Organic; BR.
08	Very weakly broken	Org./Lac; Bedrock.	Irregular	Bedrock; Organic
09	Weakly broken	Glacio-fluvial; Org./Lac; Lac./R.	Somewhat irregular	Beach; Organic
10	Very weakly broken	Org./Lac; Glacio-fluvial; R.	Irregular	Bedrock; Organic
11	Very weakly broken	Org./Lac/Till; Bedrock	Somewhat irregular	Organic; Bedrock
12	Very weakly broken	Org./Lac./Till; Beach/Till	Somewhat irregular	Clay Till; Organic
13	Very weakly broken	Org./Lac; Lac./R.	Somewhat irregular	Organic; Bedrock
14	Weakly to moderately broken	Org./Lac; Glacio-fluvial; Lac./R.	Somewhat irregular	Organic; Bedrock
15	Moderately broken	Lac./R; Org./Lac.	Irregular	Bedrock
16	Weakly broken	Lac./R; Glacio-fluvial; Org./Lac.	Somewhat irregular	Organic; Bedrock
17	Weakly broken	Org./Lac; Lac./R; Glac.-fluv.	Regular	Organic
18	Moderately broken	Lac./R; Till/R.	--	--
19	Weakly broken	Org./Lac./Till; Glacio-fluvial	Somewhat irregular	Organic; Bedrock
20	Weakly broken	Glacio-fluvial; Org./Lac; Lac./R.	Somewhat irregular	Organic; Bedrock
21	Weakly to moderately broken	Lac./R; Org./Lac.	Irregular	Organic; Bedrock
22	Weakly broken	Lac./R; Org./Lac.	Irregular	Bedrock; Organic
23	Weakly broken	Lac./R; Org./Lac.	Somewhat irregular	Organic; Bedrock
24	Weakly broken	Org./Lac; Lac/R.	Somewhat irregular	Lac; Bedrock
25	Weakly broken	Org./Lac; Lac/R.	Somewhat irregular	Organic; Bedrock
26	Very weakly to weakly broken	Org./Lac; Lac/R.	Irregular	Bedrock; Organic
27	Moderately broken	Lac./R; Org./Lac.	Somewhat irregular	Organic; Bedrock
28	Weakly to moderately broken	Lac./R; Org./Lac.	Regular	Organic
29	Weakly to moderately broken	Lac./R; Org./Lac.	Irregular	Bedrock; Organic
30	Weakly broken	Beach/Till; Lac./Till; Org./Lac.	Somewhat irregular	Organic; Bedrock
31	Weakly to moderately broken	Beach/Till; Lac./Till; Org./Lac.	Somewhat irregular	Organic; Bedrock
32	Very weakly broken	Beach/Till; Lac./Till; Org./Lac.	Regular	Organic
33	Weakly broken	Lac./R; Org./Lac.	Somewhat irregular	Organic; Bedrock
34	Moderately broken	Lac./R; Org./Lac.	Irregular	Bedrock
35	Weakly broken	Org./Lac; Lac./R.	Somewhat irregular	Organic; Bedrock
36	Weakly to moderately broken	Lac./R; Org./Lac.	Irregular	Bedrock

bio-physical classification
OUTLET LAKES AREA



LAND SYSTEMS

Topographic Class

Class	Description
Very weakly broken	Level area, less than 10% of the area occupied by low relief features, the magnitude of which is less than 25 ft.
Weakly broken	Area of long gentle slopes, or very short steep slopes. Differences in elevation generally less than 75 ft.
Moderately broken	Area of long moderate slopes or of short steep slopes. Differences in elevation less than 200 ft.
Strongly broken	Area of moderately steep long slopes or of short steep escarpments. Difference in elevation frequently in excess of 300 ft.

Depth to bedrock classes

	Clay	Loam	Silty Sand	Sand
Bare bedrock	0-1 inch	0-2 inch	0-3 inch	0-3 inch
Shallow	1-18 inch	2-24 inch	3-30 inch	3-36 inch
Deep	over 18 inch	over 24 inch	over 30 inch	over 36 inch

LEGEND. Index symbols* of land systems.

VERY WEAKLY BROKEN AREAS

Landform	Number
Bog	B
Transitional Bog	T
Fen	F
Sphagnic Fen	S
Sand	1
Loam	2
Silt	3
Clay	4
All materials	5

WEAKLY BROKEN AREAS

Bare bedrock materials	Number
Moderately resistant limestone bedrock	6
Weakly resistant argillaceous bedrock	7
Weakly resistant sandstone bedrock	8
Moderately resistant bedrock	9
Strongly resistant bedrock	10

Unconsolidated geologic material — Number

	Bare & shallow	Shallow (with bare & some deep)	Deep & shallow (with some bare)	Deep
Sand (coarse and medium)	11	21	31	41
Sand (fine and silty)	12	22	32	42
Sand (coarse to fine and silty)	13	23	33	43
Sand, with loam, silt and/or clay	14	24	34	44
Loam	15	25	35	45
Loam, with sand, silt and/or clay	16	26	36	46
Silt	17	27	37	47
Silt, with sand, loam and/or clay	18	28	38	48
Clay	19	29	39	49
Clay, with silt, loam and/or sand	20	30	40	50

MODERATELY BROKEN AREAS

Unconsolidated geologic material — Number

	Bare & shallow	Shallow (with bare & some deep)	Deep & shallow (with some bare)	Deep
Sand (coarse and medium)	51	61	71	81
Sand (fine and silty)	52	62	72	82
Sand (coarse to fine and silty)	53	63	73	83
Sand, with loam, silt and/or clay	54	64	74	84
Loam	55	65	75	85
Loam, with sand, silt and/or clay	56	66	76	86
Silt	57	67	77	87
Silt, with clay, loam and/or sand	58	68	78	88
Clay	59	69	79	89
Clay, with silt, loam and/or sand	60	70	80	90

Bare bedrock materials	Number
Moderately resistant limestone bedrock	91
Weakly resistant argillaceous bedrock	92
Weakly resistant sandstone bedrock	93
Moderately resistant bedrock	94
Strongly resistant bedrock	95

STRONGLY BROKEN AREAS

Geologic material	Number
All unconsolidated materials, deep	96
All unconsolidated materials, deep to bare bedrock	97
Bare bedrock and shallow unconsolidated materials	98

VERY STRONGLY BROKEN AREAS

Geologic material	Number
All materials	99

Modifiers

Name	Mapping Symbol	Description
Very highly calcareous	v	Free carbonates within 0-6 inches of the soil
Highly calcareous	h	Free carbonates within 6-30 inches of the soil
Moderately calcareous	m	Free carbonates within 30-48 inches of the soil
Somewhat calcareous	s	Carbonates below 48 inches of the soil, but within the rooted zone
Low base	b	10% or more basic rock fragments
Very low base	a	66% or more acidic rock fragments

Name	Symbol	Description
Localized permafrost	k	< 15% permafrost in landform component
Discontinuous permafrost	[illegible]	≥ 15% - < 50% permafrost in landform component
Widespread permafrost	[illegible]	≥ 50% - < 85% permafrost in landform component
Continuous permafrost	[illegible]	85% permafrost in landform component

* Index symbols; implications

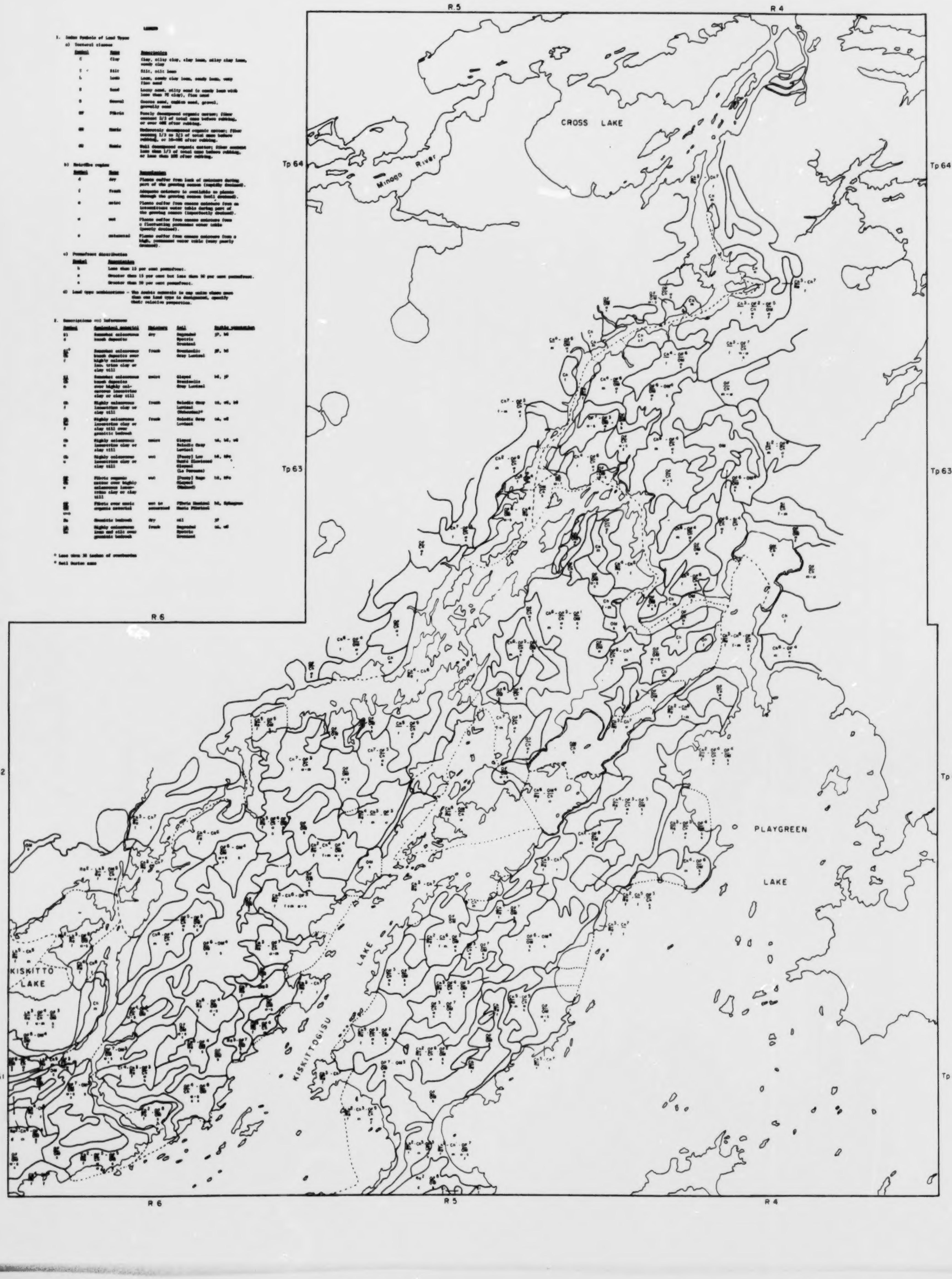
1.a) Letters before numerals; e.g. Bk-37, implies ≥50% Bk and <50% 37 in system area.

b) Numerals before letters; e.g. 39-SF, implies ≥50% 39 and <50% SF in system area.

2. Letter sequences; e.g. SB, portray that the system area contains <50% S and ≥50% B.

3. The symbols used identify at least 85% of the landform components.

land-type map
NELSON RIVER, WEST CHANNEL AREA


R.5
R4
Tp 64
Tp 63
Tp 62
Tp 61
R 6
CROSS LAKE
Minago River
PLAYGREEN
LAKE
KISKITTOGISU
LAKE
KISKITTO
LAKE

Specific areas of the reservoir site should receive primary consideration. General clearing is costly and often difficult to justify by projected returns. Funds may be more wisely spent in developing alternative sites.

The potential for a commercial fishery could be hampered by the presence of submerged or floating debris. The need for placing nets in areas that have been inundated rather than in existing water bodies should be substantiated before program of clearing to enhance commercial fishery is initiated.

The burning of forest cover and roots from specific sites to develop possible spawning grounds is a nebulus proposition. To be effective, burning should be scheduled for very dry periods. The risk from fire is a factor that may limit the usefulness of this procedure.

Perhaps potential gravel beaches or rock ledges suitable for recreation could be scoured clean to accommodate dual purposes of fish and recreation.

The use of hydraulic monitors to wash vegetative matters, silts and debris from gravelly sites is a potential method for developing spawning sites after flooding.

In general, flooded forests limit access to fish but are not in themselves a prime concern to fish populations.

3.3 WILDLIFE

The flooded portions of the forest, particularly where floatage accumulates, could have detrimental effects on large animals that attempt to swim through tangles of debris. The extent of this potential problem has not been identified.

The flooded stands of timber apparently are acceptable habitats to most small aquatic mammals and waterfowl. The flood-killed timber is utilized as nesting and roosting sites for many birds. Numerous bats have been observed in this type of habitat where insects abound. The space under the loose bark of dead trees provides daytime shelter for these nocturnal animals.

The clearing of flooded forest cover is difficult to justify from a wildlife consideration. Clearing above the floodline for a distance of about 50 feet would assist riparian vegetation to become established and thereby supplement lost browse.

3.4 SOCIAL PRESERVATION VALUES

The sight of flooded trees, particularly standing trees, is an affront to most individuals' aesthetic sensibilities.

In this period of social awareness, the social preservation values of the public are primarily concerned with maintaining natural appearing ecosystems. The actual value the public places on this concept is difficult to assess but this value is probably the prime explanation for clearing reservoir sites in remote areas.

The determination of what the people of Manitoba deem is an appropriate amount to spend for aesthetics would be a useful component in arriving at an acceptable clearing program.

Fluctuating water levels of the reservoir and the natural forces will rapidly break down the smaller components of the forest cover. Certain exposed areas may be downed within 20 years. Timber in sheltered bays appears to be capable of withstanding decay and mechanical damage for some 50 years or more.

3.5 ARCHAEOLOGY

The low discovery potential of the swampy sites combined with winter clearing where the root mat is left intact places archaeology as a minor factor in the overall design of the clearing program. Identified sites should be marked in the field and clearing supervisors informed of the implications.

3.6 FORESTRY

Logic would suggest that merchantable timber should be salvaged from reservoirs prior to flooding. Rarely is this accomplished even when timber values are high. The elements of time, poor access and limitations of markets are usually the prime deterents. The transient nature of construction operations is another difficulty where skilled loggers are required.

The stands of merchantable timber in the west channel are of marginal value. Fluctuations in log prices are difficult to predict. The high cost of financing inventories of logs is a deterent to stockpiling. Compared to alternative sources of wood supply the reservoir site is not competitive with selected blocks of accessible timber where a logging operator may have the opportunity to establish a position of some permanence.

Subsidized logging should be considered as being preferable to destroying timber. A primary use of logs from within the reservoir site that is often overlooked is the requirement for boomsticks after flooding. The larger logs should be stockpiled and bored for chains or fitted with cables prior to flooding. Several thousands of the largest white spruce trees should be selected for this anticipated need.

Methods of cutting flooded trees are being evaluated and selective underwater cutting of trees is now practical. Other recent developments in integrated systems of harvesting, processing, packaging and waste disposal have potential application to utilize small timber from the flooded reservoirs.

The allotment of development funds to construct prototype processing or disposal system may be an alternative to large-scale clearing operations with no readily defined objective.

Disposal of vegetative cover by the simple process of crushing the material into the soft bottom is an alternative and economical approach to resolving the aesthetic and possibly some of the fishery consideration. Otherwise the process does not have much to commend it.

3.7 RECREATION

Recreational use of the forebay area would focus primarily on sports fishery with secondary use of the waterway for hunting.

Clearing to date would provide ample gross area for fishermen. Further clearing should be based on developing specific sites that would appear to have particular advantages for fishing. The clearing and grubbing of channels and areas fronting access roads should be considered. There is no substitute for on-site decisions by properly qualified personnel in defining specific sites.

The clearing of creek channels and the mouths of creeks would be an obvious advantage to fishermen. Creek channels are often the only accessible routes to shore through flat areas. Clearing for wildlife development and to develop access for hunters is not necessarily compatible with the requirements of fishermen.

The piling or windrowing of debris in shallows and leaving the material in situ would create habitat nitches and platforms or blinds for hunters that would otherwise be unattainable. Some sacrifice of aesthetics would be involved but hunting advantages may be accrued.

Clearing to about two feet in elevation above the normal high water elevation or about 25 feet horizontally from the water's edge provides a reasonably natural appearing shoreline. In this region the 25-foot horizontal boundary would be most prevalent. The need to clear backshore areas to develop specific habitats for wildlife browse should be established before such a clearing program is initiated. The selection of areas for the development of alternate browse sources is dependent upon soil, aspect and patterns of animal use.

3.8 TRANSPORTATION

Both recreational and commercial users of the water system will benefit from the increased access. Waterways through flooded timber should be developed between all interconnecting water bodies and through to the new shoreline at prescribed access points. The 50-foot wide channels outlined in the guidelines are too narrow. Channels 200 feet plus would be more appropriate. For appearance sake, long channels through flooded timber should be designed with a variation of widths and reaches rather than a straight line. Channels following creeks are recommended to ensure adequate depth of water to the shore. All projected roads should be plotted and an appropriate clearing program designed for sites where road and reservoir access interrelate. Again, on-site decisions are required.

The design of a system of booms to control floatage should be evolved prior to flooding so that anchors for booms could be set on land.

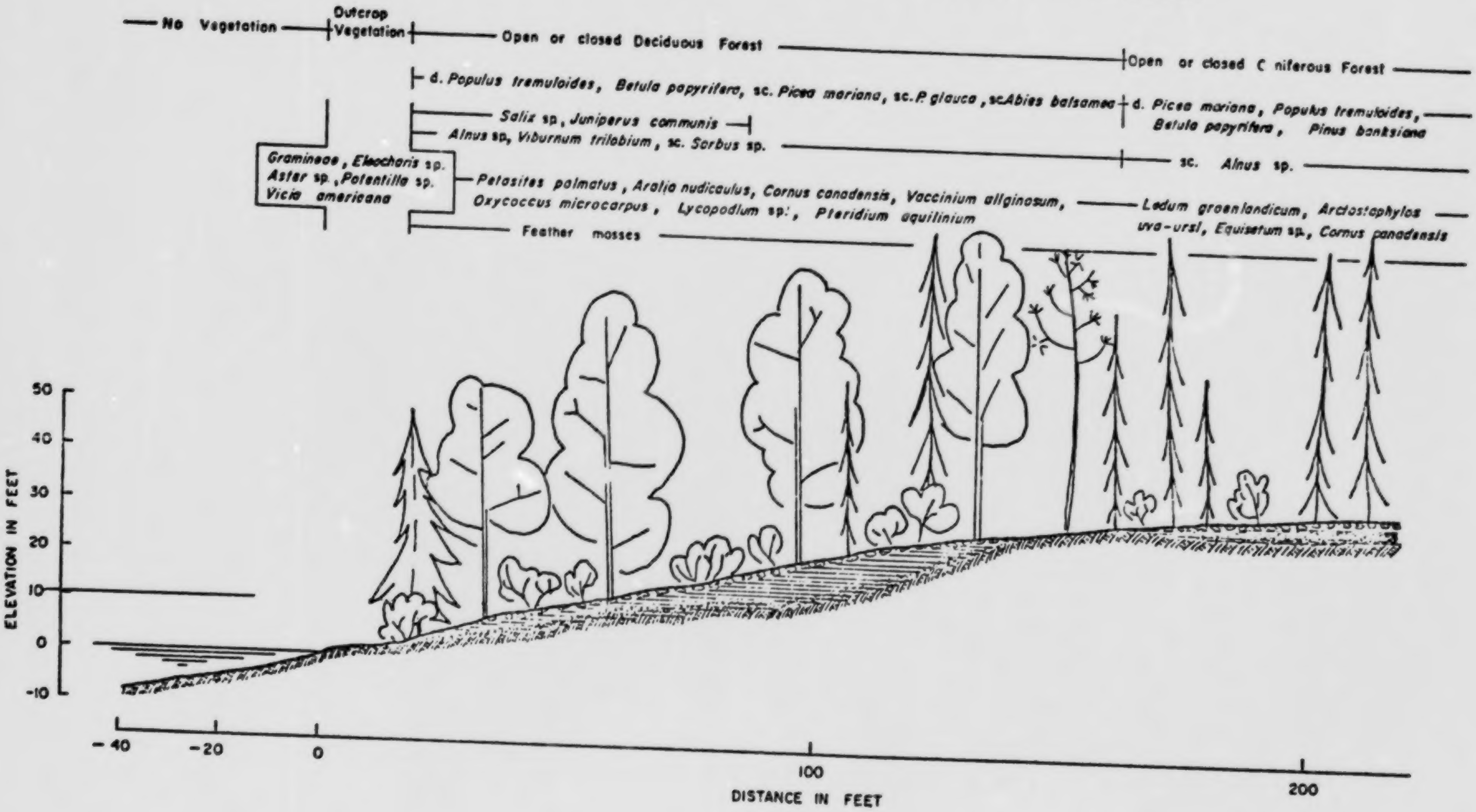
APPENDIX 101

CHARACTERISTIC SHORELINE PROFILES
R[illegible]E OF THE TERRAIN
[illegible]E OUTLET LAKES REGION

FIGURE 6

CLASSIFICATION 13

LOW BEDROCK SHORELINE

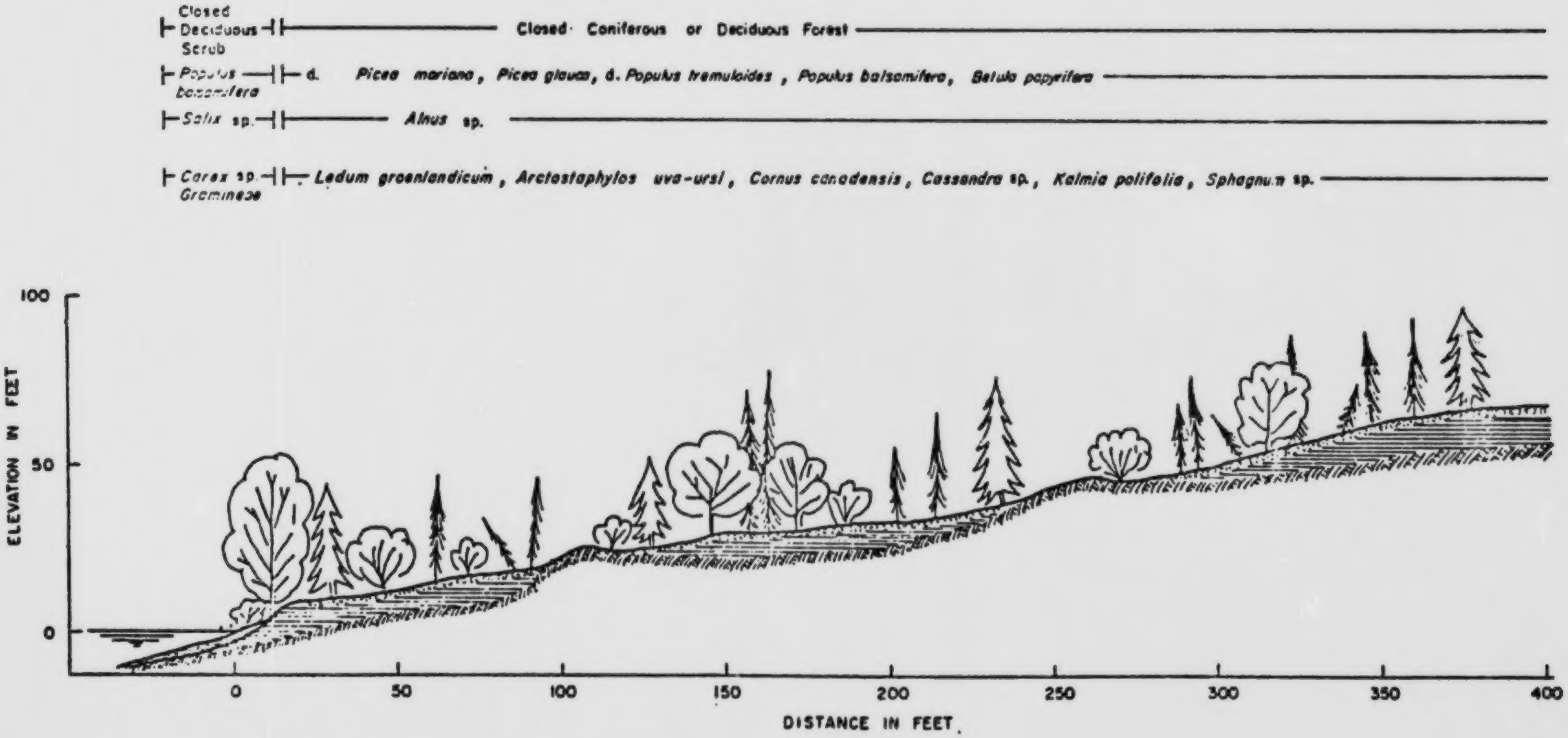

No Vegetation
Outcrop Vegetation
Open or closed Deciduous Forest
Open or closed C niferous Forest
d. Populus tremuloides, Betula papyrifera, sc. Picea mariana, sc. P. glauca, sc. Abies balsamea
d. Picea mariana, Populus tremuloides, Betula papyrifera, Pinus banksiana
Salix sp., Juniperus communis
Alnus sp., Viburnum trilobium, sc. Sorbus sp.
sc. Alnus sp.
Gramineae, Eleocharis sp. Aster sp., Potentilla sp. Vicia americana
Petasites palmatus, Aralia nudicaulus, Cornus canadensis, Vaccinium alginosum, Oxycoccus microcarpus, Lycopodium sp., Pteridium aquilinium
Ledum groenlandicum, Arctostaphylos uva-ursi, Equisetum sp., Cornus canadensis
Feather mosses
ELEVATION IN FEET
50
40
30
20
10
0
-10
-40
-20
0
100
200
DISTANCE IN FEET

SLOPE 1:5 OVERALL

FIGURE 7

CLASSIFICATION 14

BEDROCK - CONTROLLED SHORELINE
WITH OVERBURDEN BEACH

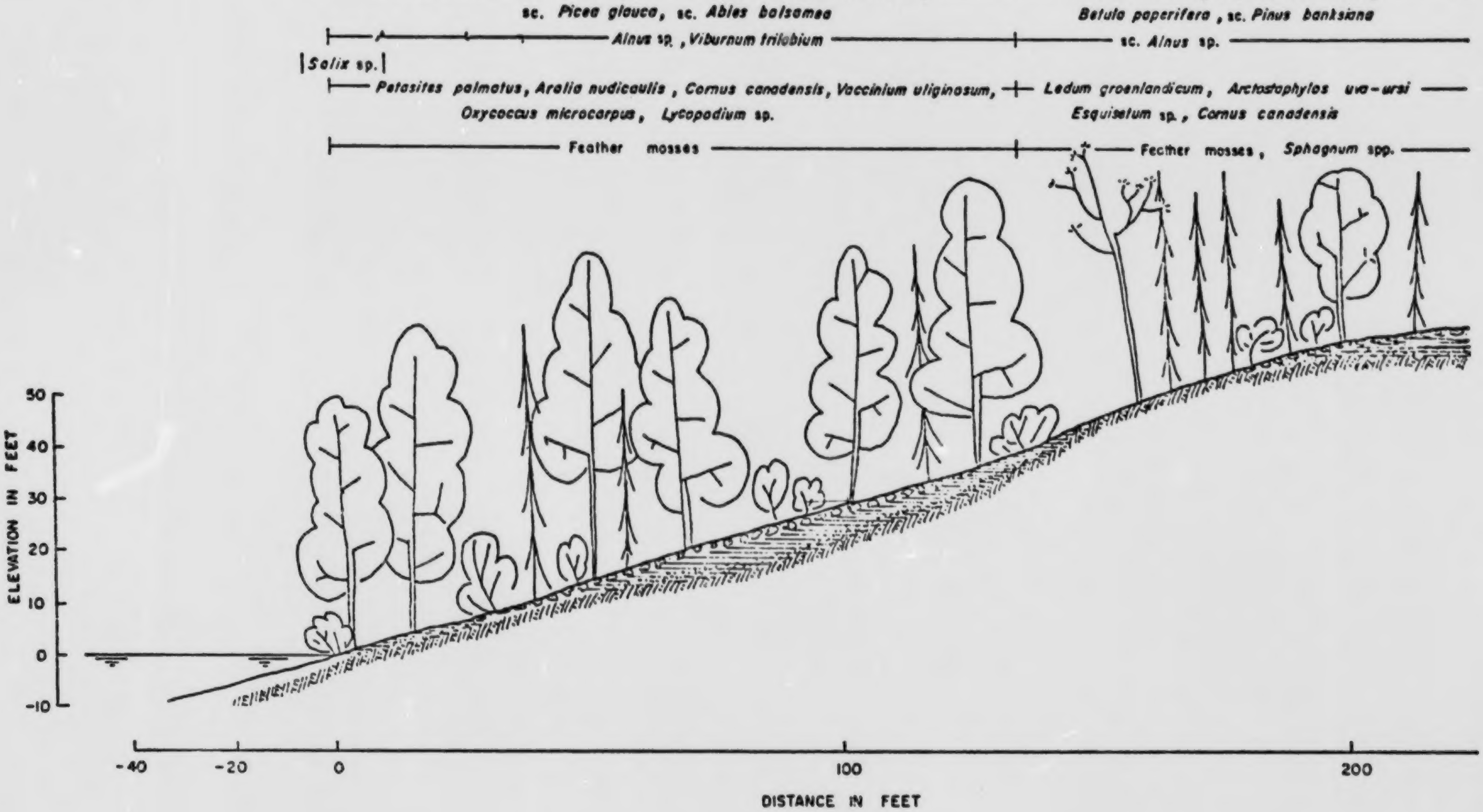

Closed Deciduous Scrub
Closed Coniferous or Deciduous Forest
Populus balsamifera
d. Picea mariana, Picea glauca, d. Populus tremuloides, Populus balsamifera, Betula papyrifera
Salix sp.
Alnus sp.
Carex sp. Gramineae
Ledum groenlandicum, Arctostaphylos uva-ursi, Cornus canadensis, Cassandra sp., Kalmia polifolia, Sphagnum sp.
ELEVATION IN FEET
100
50
0
0
50
100
150
200
250
300
350
400
DISTANCE IN FEET

SLOPE 1:5 OVERALL

FIGURE 8

CLASSIFICATION 15

LOW BEDROCK CONTROLLED SHORELINE

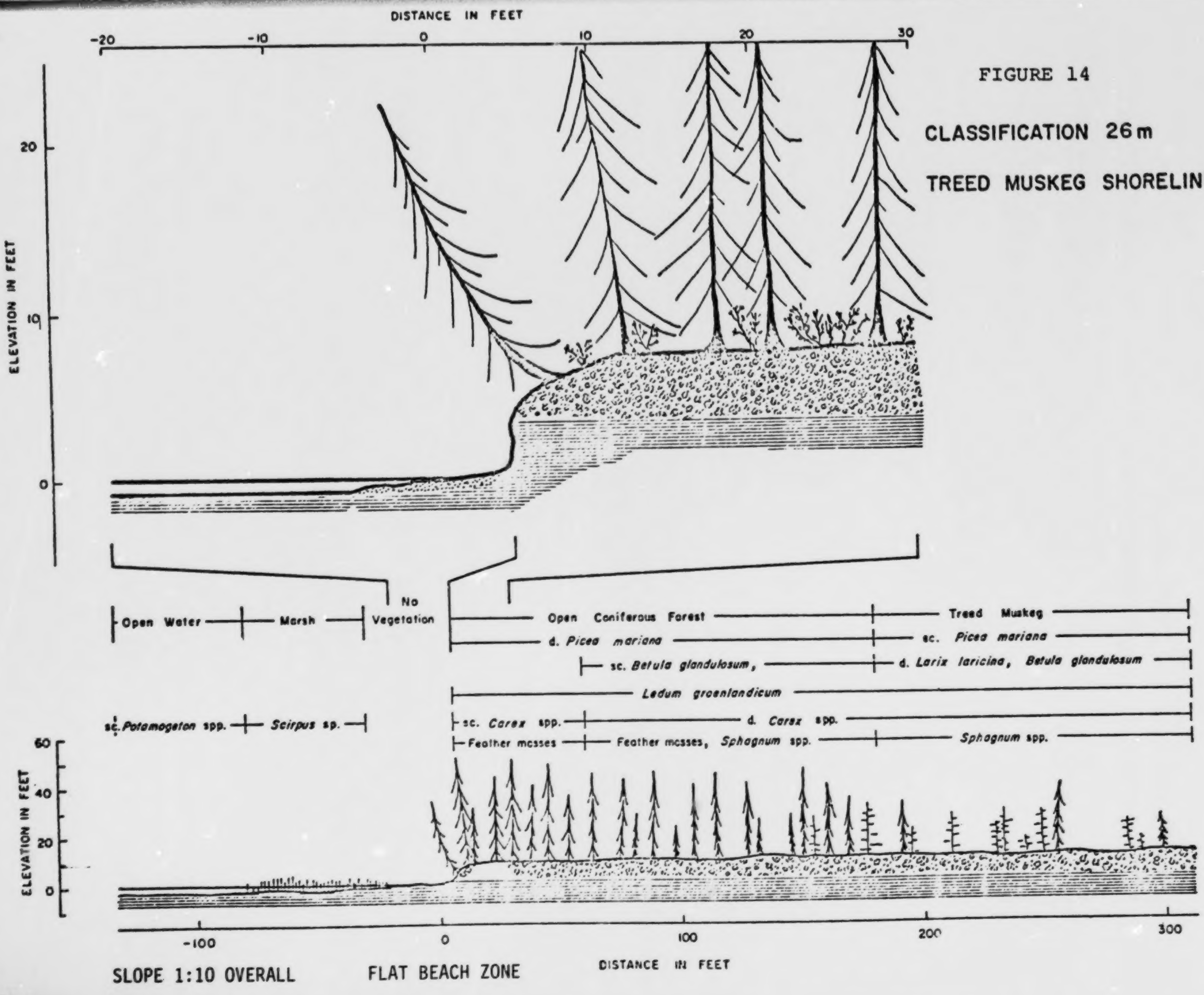

No Vegetation
Open or closed Deciduous forest
Open or closed Coniferous forest
d. Populus tremuloides, P. balsamifera, Betula paperifera, Picea mariana, sc. Picea glauca, sc. Abies balsamea
d. Picea mariana, Populus tremuloides, Betula paperifera, sc. Pinus banksiana
Alnus sp., Viburnum trilobium
sc. Alnus sp.
Salix sp.
Petasites palmatus, Aralia nudicaulis, Cornus canadensis, Vaccinium uliginosum, Oxycoccus microcarpus, Lycopodium sp.
Ledum groenlandicum, Arctostaphylos uva-ursi, Esquisetum sp., Cornus canadensis
Feather mosses
Feather mosses, Sphagnum spp.
ELEVATION IN FEET
50
40
30
20
10
0
-10
-40
-20
0
100
200
DISTANCE IN FEET

SLOPE 1:3 OVERALL

FIGURE 14

CLASSIFICATION 26m

TREED MUSKEG SHORELINE

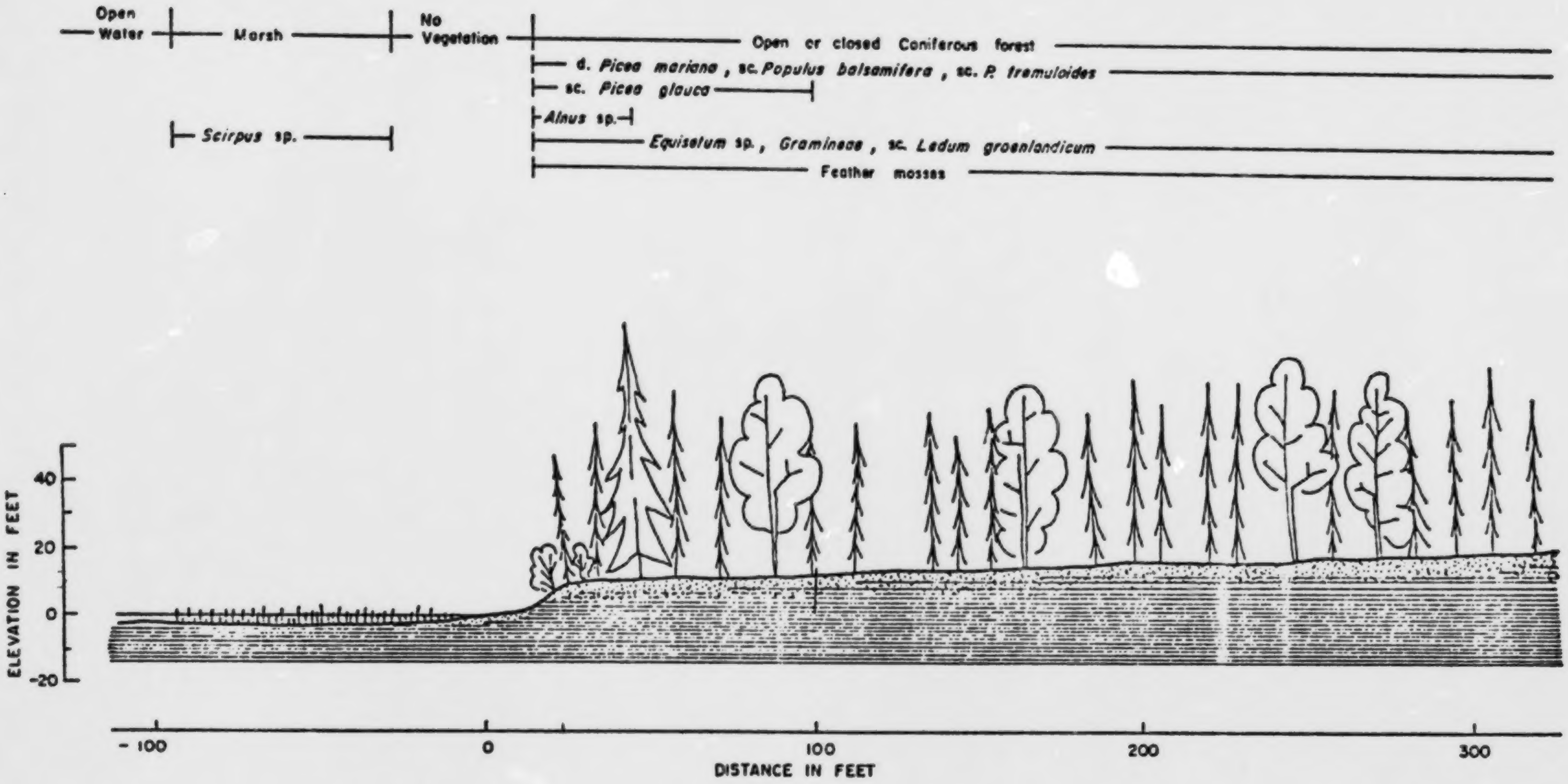

DISTANCE IN FEET
-20
-10
0
10
20
30
ELEVATION IN FEET
20
10
0
Open Water
Marsh
No Vegetation
Open Coniferous Forest
Treed Muskeg
d. *Picea mariana*
sc. *Picea mariana*
sc. *Betula glandulosum*,
d. *Larix laricina*, *Betula glandulosum*
Ledum groenlandicum
sc. *Potamogeton* spp.
Scirpus sp.
sc. *Carex* spp.
d. *Carex* spp.
Feather mosses
Feather mosses, *Sphagnum* spp.
Sphagnum spp.
60
40
20
0
ELEVATION IN FEET
-100
0
100
200
300
DISTANCE IN FEET

SLOPE 1:10 OVERALL FLAT BEACH ZONE

FIGURE 15

CLASSIFICATION 27bm

LOW SHORELINE IN COARSE SEDIMENTS

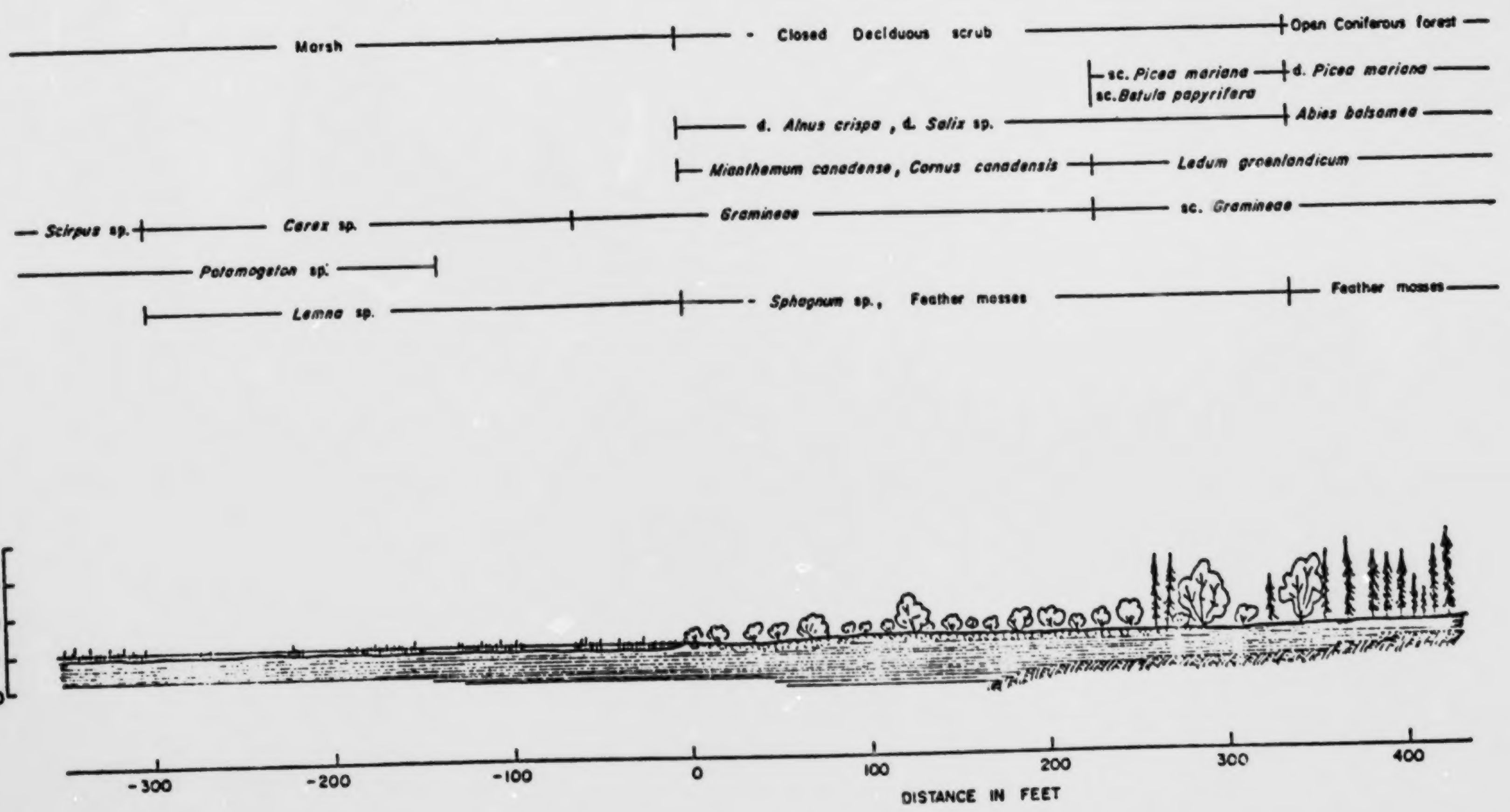

Open Water
Marsh
No Vegetation
Open or closed Coniferous forest
d. Picea mariana, sc. Populus balsamifera, sc. P. tremuloides
sc. Picea glauca
Alnus sp.
Scirpus sp.
Equisetum sp., Gramineae, sc. Ledum groenlandicum
Feather mosses
ELEVATION IN FEET
40
20
0
-20
- 100
0
100
200
300
DISTANCE IN FEET

SLOPE 1:10 OVERALL
1:25 BEACH ZONE

FIGURE 16

CLASSIFICATION 28m

LOW WILLOW SHORELINE

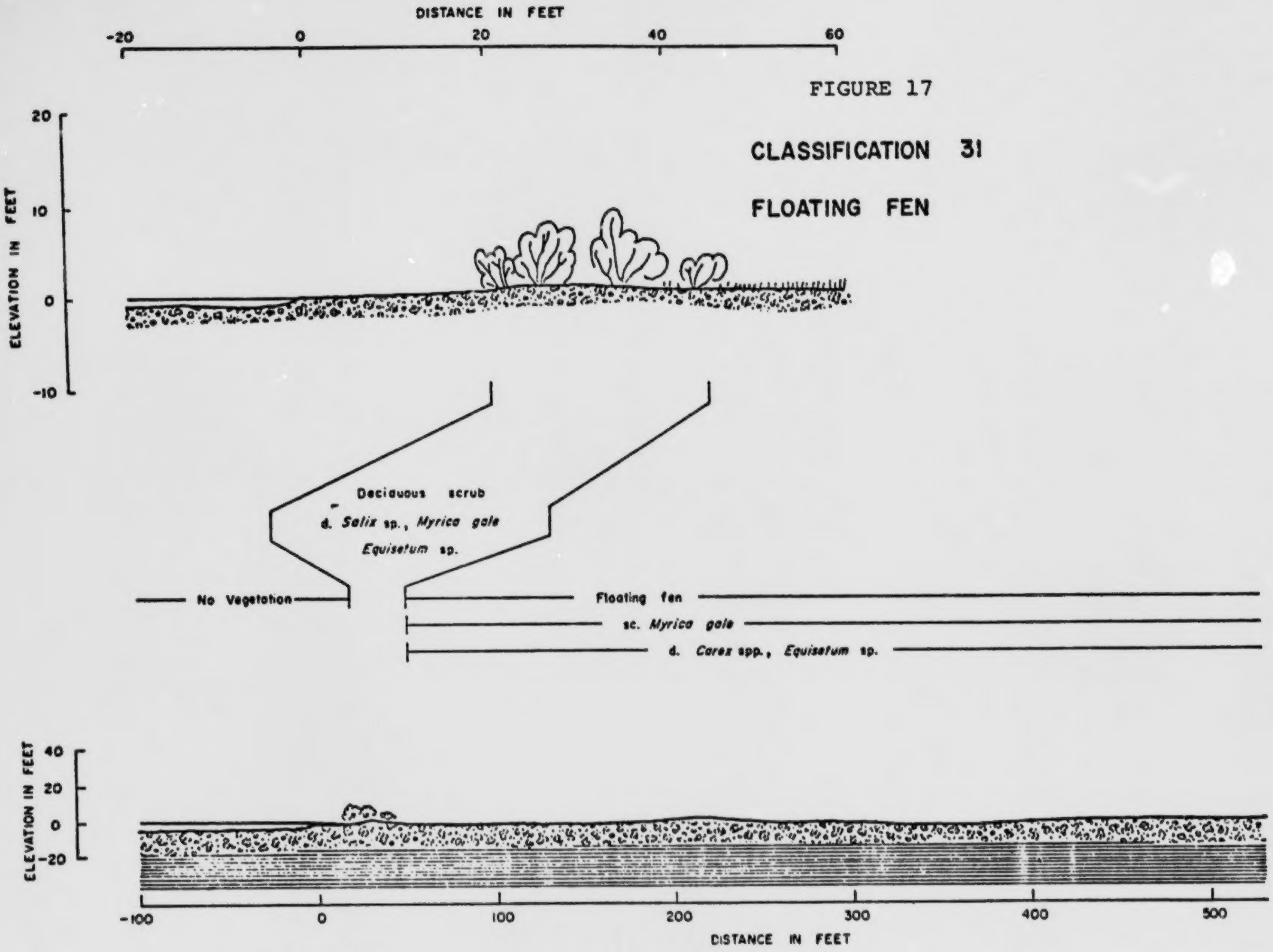

Marsh
- Closed Deciduous scrub
Open Coniferous forest
sc. *Picea mariana*
sc. *Betula papyrifera*
d. *Picea mariana*
d. *Alnus crispa* , d. *Salix* sp.
Abies balsamea
Mianthemum canadense, *Cornus canadensis*
Ledum groenlandicum
Scirpus sp.
Carex sp.
Gramineae
sc. *Gramineae*
Potamogeton sp.
Lemna sp.
- *Sphagnum* sp., Feather mosses
Feather mosses
ELEVATION IN FEET
60
40
20
0
-20
-300
-200
-100
0
100
200
300
400
DISTANCE IN FEET

SLOPE: FLAT

FIGURE 17

CLASSIFICATION 31

FLOATING FEN


DISTANCE IN FEET
-20
0
20
40
60
ELEVATION IN FEET
20
10
0
-10
Deciduous scrub
d. *Salix* sp., *Myrica gale*
Equisetum sp.
No Vegetation
Floating fen
sc. *Myrica gale*
d. *Carex* spp., *Equisetum* sp.
ELEVATION IN FEET
40
20
0
-20
-100
0
100
200
300
400
500
DISTANCE IN FEET

SLOPE: FLAT

APPENDIX 201

Province of Manitoba
Department of Mines, Resources and Environmental Management
Environmental Management Division

Research Branch
909 Norquay Building
Winnipeg, Manitoba
R3C 0P8

July 20, 1972.

Mr. George Reid,
General Manager,
Administration and Finance,
Manitoba Hydro,
820 Taylor Avenue,
WINNIPEG, Manitoba.

Dear Mr. Reid:

Re: Jenpeg Forebay Clearing

During the past few months there has been much thought given to the question of an acceptable degree and pattern of timber clearing prior to raising water levels in the Jenpeg Forebay. Following various meetings and correspondence involving representatives of Manitoba Hydro, the Department of Tourism and Recreation, Parks Branch and the Department of Mines, Resources and Environmental Management, we appear to have reached accord on the conditions for clearing. Thinking it best, for the sake of good order, I am setting out, as follows, these conditions as we understand them to be:

1. All merchantable timber to be cleared to elevation 715 feet. (Merchantable timber is defined as trees falling into the 4" diameter class and 30 feet height class and larger).
2. All islands will be cleared. (to elev 715')
3. Where the banks are steep and the difference in area between elevation 713 feet, 714 feet and 715 feet is small, clear to 715 feet.
4. Where the river banks are well defined along the main water course, clear to elevation 713 feet starting at the control structure on upstream to the junction of the West Channel and Metchanais Channel. The remainder of the channels proposed for clearing would be cleared to elevation 714 feet.

5. Where the river banks have a mild slope and flooding will occur over a wide area along and away from the natural river channel, clear to elevation 710 feet.

6. Where there are draws or flood plains away from the river which can be isolated by booms, clear to the boom location.

7. Clear to all dykes that will have water against them. Freeboard dykes are excluded.

8. Clear areas required for docks and/or landings.

9. Clear and grub any area designated as a recreational area.

10. Provide cleared areas to ground level at intervals of three miles along the navigation channel to allow an approach to the shoreline in order that boats could be launched at these locations, or to provide access to the shoreline.

11. Within four years following the completion of the Jenpeg project, should the Department of Mines, Resources and Environmental Management in consultation with Manitoba Hydro decide that additional clearing should be performed, Manitoba Hydro would undertake to have this clearing performed through periods of low water, provided the expenditure associated with this additional clearing will not exceed $1,000,000.00.

Such conditions as stated above are respected as practical measures to alleviate damage to the environment and their intent is regarded as acceptable by the Environmental Division of the Department of Mines, Resources and Environmental Management. It is my understanding that they are similarily acceptable to the Department of Tourism and Recreation, Parks Branch - in particular, the special treatment indicated to your Mr. Jack Callum by Mr. W. W. Danyluk as being required for three identified recreational sites on the main channel.

I trust that Manitoba Hydro agrees that the above represents an accurate description of mutually acceptable conditions for clearing. If you find that you require further information and/or clarification from us, I would be grateful if you will advise me as soon as possible.

Yours truly,

W. George Bowen

W. George Bowen,
Assistant Deputy Minister.

WGB/si

c.c. Hon. E. Schreyer
Hon. L. Evans
Hon. L. Desjardins
Mr. R. A. Wallace
Mr. O. S. Eagleton
Mr. J. Callum
Mr. H. Hopper
Mr. D. E. Cline
Mr. J. Collinson
Dr. K. Doan
Mr. A. Kotowycz
Mr. M. Kaye

APPENDIX 3 - H

SHORELINE GEOLOGY OF THE WEST CHANNEL
OF THE NELSON RIVER
AND NORTHEST KISKITTO LAKE

SHORELINE GEOLOGY
OF THE WEST CHANNEL OF THE NELSON RIVER
AND NORTHEAST KISKITTO LAKE

by

K. A. PHILLIPS
Mines Branch
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba
June, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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ABSTRACT

Precambrian rocks, now striking predominantly northeast in the West Channel of the Nelson River and the adjacent part of Kiskitto Lake, fall within a zone of strong northeasterly dislocation and have been subjected to varying degrees of cataclasis. The rocks comprise migmatites and flaser gneiss, probably derived in part from a metasedimentary sequence, intruded by gabbroic intrusions, and regionally metamorphosed to the upper amphibolite facies. The latter was accompanied by widespread anatexis of the more felsic rocks, accompanied or followed by limited (parautochthonous) intrusion of granite-pegmatite. Late faulting and shearing under greenschist facies conditions, and the injection of a few diabase dykes, comprise the final events in the area.

INTRODUCTION

The present work was initiated in 1972 as part of the Lake Winnipeg, Churchill and Nelson Rivers Study. This study, financed jointly by the Federal and Provincial Governments, was set up to investigate the effects of the proposed Hydro projects in northern Manitoba. The present geological work was essentially restricted to an examination of outcrops in the West Channel of the Nelson River. These outcrops will be inundated when the Jenpeg dam becomes operational. The northeasternmost part of Kiskitto Lake was also mapped to obtain supplementary information about the rocks of the West Channel. Field work was carried out by a two-man party from early June to mid-August, 1972.

The area mapped comprises a 26-mile long strip extending diagonally across the Metchanais Rapids sheet (N.T.S. area 63J-8). The West Channel receives water from Kiskittogisu Lake, about 4 miles to the southeast, via Kisipachewuk, Metchanais and Ominawin Rapids, and flows northeastward over Manitou Rapids which mark the entrance to a narrow stretch of fast water several miles long adjoining Ross Island. These four sets of rapids mark the limits of the field work to the southeast and northeast. Jenpeg is situated three miles north of the edge of the Metchanais Rapids sheet, where the Nelson River discharges from the West Channel into Cross Lake. The Cross Lake area (which includes the Jenpeg site) was mapped by Rousell (1965), but neither the Metchanais Rapids sheet nor the West Channel itself had been previously mapped, apart from recent reconnaissance work by Bell for the Geological Survey of Canada, as yet unpublished.

The writer wishes to acknowledge the valuable assistance rendered by Milos Milinkovic throughout the project. A local guide, Angus McKay, was employed for two weeks during the field season. Access to the area was by float plane from Norway House, some 35 miles to the southeast. Supply and communication services were ably provided by the Chief Conservation Officer (Norway House), Mr. D. W. Allen.

GENERAL GEOLOGY

Five principal map-units have been delineated, all Precambrian in age. These units trend predominantly in a northeasterly direction, and dip to the southeast. Owing to the limited area of the investigation, it has not been possible to make a regional evaluation of these units, and their apparent relationships may prove to be of only local significance. The local sequence is summarized in Table 1.

Table 1: Table of Formations

PRECAMBRIAN	6	Diabase
	5	Quartz monzonite to biotite granite and granodiorite; coarse-grained, commonly pink and pegmatitic
	4	Gabbro, minor norite, altered derivatives; coarse to medium-grained, massive to slightly foliated
	4a	Norite, pyroxene gabbro
	4b	Hornblende gabbro, and pegmatitic gabbro
	3	Hornblende-biotite paragneiss; finely layered and containing abundant small bodies of pegmatitic gabbro and meta-gabbro (4); considerably intruded by microcline pegmatite (5)
	2	Migmatitic tonalitic-granodioritic gneiss; medium to coarse-grained, grey and pink; abundant small lenses and layers of amphibolite (2a)
	1	Fissile, flaser and augen gneisses; groundmass dark grey, mylonitic; weathered surface uniformly pale grey, showing coarse tabular, buff-coloured feldspar porphyroclasts

Flaser gneiss (1) extends southwest from Ross Island, and appears to grade into migmatitic tonalite-granodiorite gneiss (2) near Metchanais Rapids. The latter occurs extensively in the southwestern part of the map-area (especially around Kiskitto Lake), together with hornblende-biotite gneiss (3). Abundant basic inclusions occur in the hornblende-biotite gneiss, and may be related to a major basic intrusive complex which is inferred from magnetic data (Federal-Provincial aeromagnetic Map 2588G) to underlie the area northeast of Kiskitto Lake. The hornblende-biotite gneiss (3) may in part represent a hybrid contact zone of such a basic intrusive complex, but is probably mainly sedimentary in origin. Small sill-like gabbroic intrusions (4) are common in the map-area. The youngest map-unit in the area is intrusive quartz monzonite (5) which contains an abundant pegmatitic phase. Microcline-bearing pegmatites from this source are common in map-units 1 to 4, especially in the contact zones of the quartz monzonite. The quartz monzonite grades into tonalitic-granodioritic gneiss (2).

Parts of the basic suite (4) are stated by Bell (1972, personal communication) to be correlatable with his unit 7a near Pipestone Lake, Hairy Lake and Butterfly Lake in the Cross Lake area (Bell, 1962). These rocks were shown as post-Cross Lake Group by Bell, and Rousell (1965) mapped similar basic rocks (his unit 5) at the same relative position in the sequence. The writer's flaser gneiss (1) extends into the Cross Lake area where it was mapped by Rousell (1965) as feldspar porphyry gneiss (his unit 9d) and considered to post-date the basic rocks (his unit 5). Hence the apparent sequence in the West Channel area may well require modification when observations are extended further afield.

Flaser gneiss (1)

The flaser (augen) gneiss extends about 9.5 miles (15 km) southwest from the northeast corner of the map-area, and has a width of at least 2.5 miles (4 km). Further to the northeast, the gneiss persists to the south shore of Cross Lake. A second, irregular body of the gneiss, about 2 miles (3 km) long, occurs at the northeastern end of Kiskitto Lake. Outcrops of the gneiss are characterized by:

i) homogeneous appearance;

ii) uniform pale grey weathered surface, contrasting with a darker grey colour on fresh surface;

iii) disseminated, grey to buff feldspar porphyroclasts, up to 2.5 cm in diameter;

iv) prominent cataclastic fabric;

v) strong fissility and prominent layering.

The rock contains feldspar augen, up to 2.5 cm across, and elongated quartz ribbons (2 or 3 cm), set in a fine to medium-grained, moderately dark grey groundmass. Comminuted quartz and feldspar grains in the groundmass range in size from 0.1 to 0.5 mm. Streaks of finely comminuted mica commonly swirl around lensoid quartzo-feldspathic aggregates and augen, and small altered flakes of biotite also form ragged clots (0.2 to 0.5 mm). A later generation of biotite appears in places as random flakes, associated with quartz, and some fine biotite has developed along the cleavage in oligoclase. Micro-augen structures are readily apparent in some thin sections, especially those from outcrops marked by strong fissility. The principal feldspar is oligoclase (36 to

65 per cent of the rock), accompanied or partly replaced by microcline (2 to 26 per cent). Most of the larger plagioclase crystals (2 mm to 2 cm) are either rounded, stretched, sericitized, zoned or partly recrystallized. A later generation of smaller, fresher plagioclase, some of it more sodic than the megacrysts, has developed around the margins of the latter, and also in the matrix. Microcline, showing a similar overall size range to the plagioclase, forms tabular or ovoid megacrysts and also occurs in the groundmass. Field and laboratory evidence indicates that the microcline is later than most of the plagioclase. Quartz (19 to 42 per cent) and biotite (3 to 12 per cent) are the other main constituents of the rock. Common accessory minerals are carbonate, sericite and chlorite.

Tonalitic-granodioritic gneiss (2)

This unit is a grey, medium to coarse-grained, holocrystalline, foliated migmatite, containing considerable amounts of pinkish to buff, coarse pegmatitic material. The latter occurs as lits, layers and irregular masses, which grade into or cut the grey groundmass. In many places the pegmatitic lits impart a crude layering to the rock. The unit (2) was mapped southwestward from Metchanais Rapids for about 17 miles (27 km) and persists beyond the map-boundary through Kiskitto Lake. About 2 miles (3 km) northeast of Kiskitto Lake, hornblende-biotite gneiss (3) separates the tonalitic gneiss into two zones, the larger of which strikes through the lake, while the other may be connected with tonalitic gneiss mapped at Kisipachewuk Rapids, further to the south-southwest. Contacts between the gneiss (2) and quartz monzonite (5) are irregular and gradational.

The tonalitic phase of the unit (2), in which 90 per cent of the feldspar is plagioclase, typically contains numerous lenses of amphibolite (2a) some of which are as much as 1 km in length and are shown on the geological map. Most amphibolite (2a) lenses are much smaller, and some are partially assimilated by the host rock. The tonalitic gneiss is pale to dark grey, and shows the following features:

i) presence of biotite-rich layers or partings;

ii) alternation of coarse feldspathic layers (plagioclase 3 to 8 mm) and finer grained feldspathic bands;

iii) elongation of quartz aggregates into "ribbons" 2 cm or so in length; (these are less abundant than in map-unit 1).

The tonalitic gneiss generally consists of about 50 per cent plagioclase, 30 per cent quartz, 10 per cent biotite and less than 10 per cent microcline. The plagioclase forms megacrysts (0.5 to 2 cm) which are white to pinkish in colour and appear in outcrop to be subhedral to euhedral. Under the microscope, however, the megacrysts are seen to represent an early generation of zoned, corroded and partially recrystallized oligoclase (An_{25-30}), which is accompanied by less altered plagioclase in the groundmass. This fresher plagioclase also forms a few larger crystals (1-2 mm) which, while commonly zoned, tend to be more calcic (An_{28-37}, less commonly An_{40-50}) than the older megacrysts. Microcline, where present, occurs as small, fresh, later crystals in corroded, altered plagioclase; and also forms euhedral crystals (0.5 mm and less) in the groundmass. Quartz occurs as (i) curving, elongated plates, (ii) aggregates of comminuted grains (cataclastic texture); (iii) myrmekitic intergrowths with feldspar; and (iv) small blebs in altered plagioclase. Biotite forms fresh, disseminated flakes and clusters, or undulating foliae of smaller grains. Common accessories are sericite and carbonate formed from the alteration of plagioclase, green hornblende associated with the biotite, and epidote or clinozoisite.

Granodioritic gneiss (2), in which one-third to one-tenth of the feldspar is microcline, is less abundant than the tonalitic phase into which it grades. Megascopically it is distinguished from the grey tonalitic gneiss by a greater amount of pink pegmatitic material it contains. This pegmatite contains abundant microcline, and is considered to have been introduced at the same time as the granite-pegmatite intrusion (5). Much of the microcline in the gneiss forms a mosaic with quartz and is interstitial to the plagioclase megacrysts, but some porphyroblasts of microcline, up to 1.5 cm, are also present. Some of the latter are rimmed by comminuted quartz, and others contain inclusions of plagioclase, quartz or biotite. Some of the microcline porphyroblasts contain relict cores of altered plagioclase, and replacement blebs of microcline are common in many of the plagioclase megacrysts. Breakdown of plagioclase has given rise to much white mica which in places cuts the microcline. The older zoned plagioclase megacrysts are calcic oligoclase (An_{24-30}), while a later generation of fresher plagioclase (commonly interstitial) tends to be more calcic (An_{30-33}, rarely An_{36}). The average composition of stained slabs and thin sections of typical granodiorite gneiss (2) was estimated as 55 per cent plagioclase, 25 per cent quartz, 12 per cent microcline, 6 per cent biotite, and 2 per cent sericite, carbonate, magnetite, epidote and clinozoisite.

Amphibolite (2a)

Small lensoid inclusions of amphibolite are abundant in the tonalitic gneiss (2). Larger, concordant bodies occur 4 miles (5.5 km) west of Metchanais Rapids. The amphibolite is a medium-grained rock, generally foliated, and composed essentially of fresh euhedral hornblende and labradorite. The larger bodies are gneissic, and contain greater amounts of biotite and quartz.

Hornblende-biotite gneiss (3)

The main occurrences of the hornblende-biotite gneiss in the map-area are:

i) on the north shore of Kiskitto Lake near the western map-boundary;

ii) on the south shore of Kiskitto Lake;

iii) in the West Channel where a large lenticular mass of the gneiss strikes northeast from a point 1.5 miles (2.5 km) northwest of Kisipachewuk Rapids for a distance of nearly 7 miles (11 km);

iv) numerous narrow lenses up to a mile in length (but mostly too small to show on the map) within the flaser gneiss (1).

The diagnostic features of this map-unit in the field are:

i) prominent and persistent compositional layering with marked colour contrast between almost black (amphibolitic) layers and near white (quartzo-feldspathic) layers;

ii) presence of numerous lenses and sill-like remnants of pegmatitic gabbro and meta-gabbro (4b);

iii) sparse, concordant layers (0.5-2 cm) of pink pegmatite, becoming thicker and more abundant in quartz monzonite (5) contact zones, e.g. near Kiskitto Lake.

It is inferred that the gneiss was probably derived from a metasedimentary sequence, intruded by numerous sills of gabbro (unit 4) and subsequently metamorphosed to the upper amphibolite facies with accompanying pegmatite intrusion (related to map-unit 5).

The dark layers (grey to almost black) are usually one to several centimeters thick and contain abundant biotite and hornblende. The leucocratic layers (white to buff) are generally narrower (0.5 to 2 cm) and consist mainly of andesine or labradorite and quartz, together with variable amounts of potassium feldspar. The hornblende and biotite show a preferred orientation. The hornblende occurs as fresh euhedral crystals (0.5 to 1 mm) pleochroic from yellowish to bluish green. Biotite is commonly intergrown with the hornblende, which it has partially replaced. Plagioclase ranges in composition from An_{33} to An_{55}, and in size from 0.5 to 7 mm. Many of the larger crystals are relics of earlier megacrysts that are now corroded and partially recrystallized. The smaller crystals are largely unaltered and interstitial. Microcline, where present, is commonly interstitial and associated with quartz. The latter occurs as large platy aggregates (1 to 2 cm long), and also as comminuted grains in the groundmass. Common accessory minerals in this rock are carbonate, magnetite, apatite, chlorite, clinozoisite and sericite.

Gabbro and altered derivatives (4)

Several concordant bodies of gabbro, some of them a mile or more in length, were mapped in tonalitic gneiss (2) west of Metchanais Rapids, and on Kiskitto Lake. Numerous small lensoid bodies, many too small to portray on the map, were also noted in the flaser gneiss (1) and the hornblende-biotite gneiss (3).

Norite and pyroxene gabbro (4a), though relatively rare, are well exposed on the north shore of Kiskitto Lake, and on a small island one-half mile southwest of this point. Two small bodies occur in the West Channel about 3 miles (5 km) north-northeast of Metchanais Rapids.

Hornblende gabbro (4b) is more widespread, with good exposures in the area southwest and northeast of Metchanais Rapids. Hornblende gabbro is less common on Kiskitto Lake but was found on an island 3.6 miles (5.9 km) west of the West Channel.

Norite and pyroxene gabbro (4a)

Norite from Kiskitto Lake is almost black, has a grain size of about 2 mm, and consists of about 40 per cent labradorite (An_{64}) in fresh laths, set in aggregates of hypersthene (45%) partly replaced by brown hornblende, green actinolite and magnetite (5%)*. Pyroxene gabbro contains only clinopyroxene (13%) accompanied by greenish brown hornblende (20%) and chlorite (17%). The latter has replaced the amphibole in narrow shear zones. The plagioclase, which comprises 48 per cent of the rock, is andesine (An_{49}) containing small scattered quartz blebs. On a small island in the West Channel, northeast of Metchanais Rapids, a small sill of almost black noritic gabbro, dipping 45 degrees to the northwest, is composed of 45 per cent fresh labradorite (An_{64}) laths (1 to 10 mm) set in an altered groundmass of pyroxene (20%), amphibole (25%), magnetite (8%) and serpentine. The altered pyroxene aggregates (7 mm) contain both hypersthene and clinopyroxene, associated with green hornblende and secondary tremolite-actinolite. Almost a mile downstream, another small body of norite occurs in the flaser gneiss (1) near the northeast tip of a larger island. The norite here is a weakly foliated, coarse green and white rock with dark ferromagnesian aggregates (up to 4 cm) set in a felsic matrix. The dominant mafic mineral is hypersthene (3 mm), occurring in ragged symplectic aggregates which also contain secondary green amphibole (10%) and skeletal magnetite (5%). Small laths of labradorite (An_{56}) form a felted groundmass (35%) together with accessory amounts of fine-grained quartz and biotite.

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* About 1 km to the south a small fine-grained sill contains intergrown almandine and hypersthene, major amounts of labradorite (An_{60}) and green hornblende, and accessory magnetite, biotite and quartz.

Hornblende gabbro (4b)

Hornblende gabbro, which is more common than the pyroxene-bearing types, constitutes several of the larger bodies shown on the map, and numerous smaller occurrences. Many small sill-like bodies of coarse pegmatitic gabbro (4b) occur within hornblende-biotite gneiss (3). These rocks grade into more equigranular hornblende gabbro and are readily recognized in the field by their coarsely crystalline euhedral plagioclase, commonly several centimeters in size. Common accessories are magnetite, carbonate, clinozoisite and chlorite; less common are sphene and epidote, and in some more altered varieties a little quartz and microcline may be present. Pegmatitic gabbro, from a small island in the extreme southwestern corner of the map-area, is a coarse, dark grey, unfoliated rock consisting of about 86 per cent coarse euhedral bytownite (An_{72}), interstitial hornblende (11%) and magnetite (1.5%). Extensive alteration has produced biotite, chlorite and carbonate. Pegmatitic gabbro was also found 5.6 miles (9.2 km) southwest of Metchanais Rapids, where it has the form of a lenticular body with a length of about one-half mile (0.8 km). The coarse euhedral plagioclase (0.5 to 2 cm) is zoned labradorite (An_{65}), comprising about 70 per cent of the rock and containing small inclusions (0.25 mm) of hornblende. Labradorite also occurs as small fresh euhedral crystals down to 0.5 mm in size. Interstitial hornblende (25%) forms aggregates (1 cm) of euhedral crystals (2 to 5 mm). Biotite (5%) forms rare 5 mm blades that cut labradorite and hornblende, and is also found as minor alteration patches in hornblende; sparse aggregates (1 cm) of euhedral biotite show magnetite cores and contain accessory chlorite.

A greenish black hornblende gabbro sill is exposed for approximately one mile (1.6 km) where it intrudes tonalitic gneiss (2) 1.5 miles (2.5 km) west-southwest of Metchanais Rapids. The gabbro has an average grain size of 2 to 3 mm and contains 52 per cent bytownite (An_{72}) as fresh megacrysts (3 to 5 mm) and interstitial euhedral crystals (0.5 to 2 mm). Green hornblende forms interstitial aggregates (up to 5 mm) and is also dispersed in small specks and shreds. Magnetite (4%) forms small aggregates (1 to 2 mm). Other accessories are biotite, carbonate and clinozoisite.

Hornblende meta-gabbro (4b), containing minor amounts of quartz and biotite occurs locally where gabbroic bodies are cut by pegmatite, e.g.

in a large bay 1.5 miles (2.5 km) north-northeast of Metchanais Rapids. The meta-gabbro is dark grey to black, and relatively fine-grained (1-2 mm). It contains about 47 per cent euhedral plagioclase (An_{40-58}), 33 per cent fresh hornblende, 10 per cent quartz in blebs and veinlets, 8 per cent biotite, and accessory sphene, magnetite, epidote and pyrite.

Quartz monzonite-granodiorite, granite-pegmatite (5)

This map-unit forms a number of irregular coarse-grained plutonic bodies which have gradational contacts with the tonalitic-granodioritic gneiss (2). In the field, the more granitic rocks are pink and pegmatitic, whereas granodioritic varieties weather pale grey. Locally the rocks are well foliated. The quartz monzonite-granodiorite (5) contains abundant pegmatite, and microcline-bearing pegmatite from this source, occurring as veins, dykes, sills and irregular masses, cuts all earlier map-units.

The main occurrence of this unit is a large mass between Kiskitto Lake and the West Channel, northwest of Kisipachewuk Rapids. This body is about 2.5 miles (4 km) wide at its northeast end where it is in sharp, concordant contact with hornblende-biotite gneiss (3), and gradational contact with tonalitic-granodioritic gneiss (2). A smaller body with apparent dimensions of 0.5 x 2.75 miles (0.8 x 4.5 km) extends further southwest beyond the larger mass, from which it appears to be separated (on the basis of aeromagnetic interpretation) by a narrow zone of hornblende-biotite gneiss (3). The northwestern contact of this smaller body with the gneiss (3) is well exposed along the shore of the lake, and the concordant, intrusive nature of the pluton is clearly demonstrated by: (a) increased fissility of the contact gneiss; (b) lit-par-lit penetration of the gneiss; and

(c) presence of narrow xenoliths of the gneiss in the quartz monzonite. Further to the northwest in Kiskitto Lake, a smaller body of quartz monzonite-granodiorite is indicated by scattered island outcrops and aeromagnetic data. The inferred length of this body is about 2 miles (3 km), with a maximum width of less than one-quarter mile (0.2 km) but contacts are not exposed. Another body, again elongated in a northeasterly direction, is exposed over a length of about 5 miles (8 km) and a maximum width of 1 mile (1.6 km) in the West Channel, west of Metchanais Rapids. Near its southern end, this body is in sharp contact with hornblende-biotite gneiss (3), but its contacts with the tonalitic-granodioritic gneiss (2) and flaser gneiss (1) are again gradational.

Laboratory studies show that the quartz monzonite-granodiorite has a typical composition of 37 per cent plagioclase, 33 per cent quartz, 22 per cent microcline, 6 per cent biotite and 2 per cent accessories. The more granitic rocks contain more microcline (37%) but less plagioclase (27%), quartz (29%) and biotite (4%). Thin sections of both types show an early generation of zoned, corroded megacrysts of sericitized plagioclase (An_{24-32}). Interstitial and larger crystals (0.25-0.5 mm) of a later generation of plagioclase have a composition of An_{27-33} (rarely An_{36}) for granodiorite, and An_{25-27} (rarely An_{32}) for granite. Microcline is fresh, interstitial (0.25-0.5 mm), or porphyroblastic (0.5-1.5 cm). It is associated with quartz and commonly occurs as replacement blebs in the early generation of plagioclase. Some of the microcline porphyroblasts contain remnants of altered plagioclase. Much of the quartz is in large plates or platy aggregates, some of which are 2 cm long. Finer, comminuted quartz is common in the groundmass. Minor biotite occurs as fresh interstitial flakes, weakly oriented in some cases, and in places shredded. It is accompanied by subsidiary white mica in minor to accessory amounts, clearly derived from breakdown of early plagioclase; carbonate from this source is also a common accessory. Other accessory minerals are magnetite, apatite, epidote, clinozoisite and hematite.

Typical pegmatite contains microcline (up to 3 cm in diameter and constituting as much as two-thirds of the rock), quartz and minor plagioclase. The plagioclase occurs as highly altered remnants, surrounded and partially replaced by microcline. Biotite may be present in minor amounts, and is considerably chloritized. Accessory minerals are apatite and hematite, the latter occurring as earthy material along cleavage planes in the microcline.

Diabase (6)

Diabase dykes, ranging in width from 5 cm to 3.5 m, are sparsely distributed throughout the map-area (Figure 1). Approximately half of the dykes strike northeast; the rest strike either northwest or north, rarely east. Most of the dykes dip steeply to the northwest. The dykes cut all other rock types except for the pegmatitic granite (5).

Most of the dykes consist of pyroxene diabase. A few were identified as hornblende diabase. Typical examples of pyroxene diabase occur on the southern shore of Kiskitto Lake, e.g. 2.5 miles (4 km) from the southwest corner of the map-area. Euhedral phenocrysts (0.25 to 1 mm) of orthopyroxene are common, while clinopyroxene phenocrysts are generally subordinate. Fresh labradorite laths occur with clinopyroxene in the groundmass and as phenocrysts. Poikilitic texture is found locally.

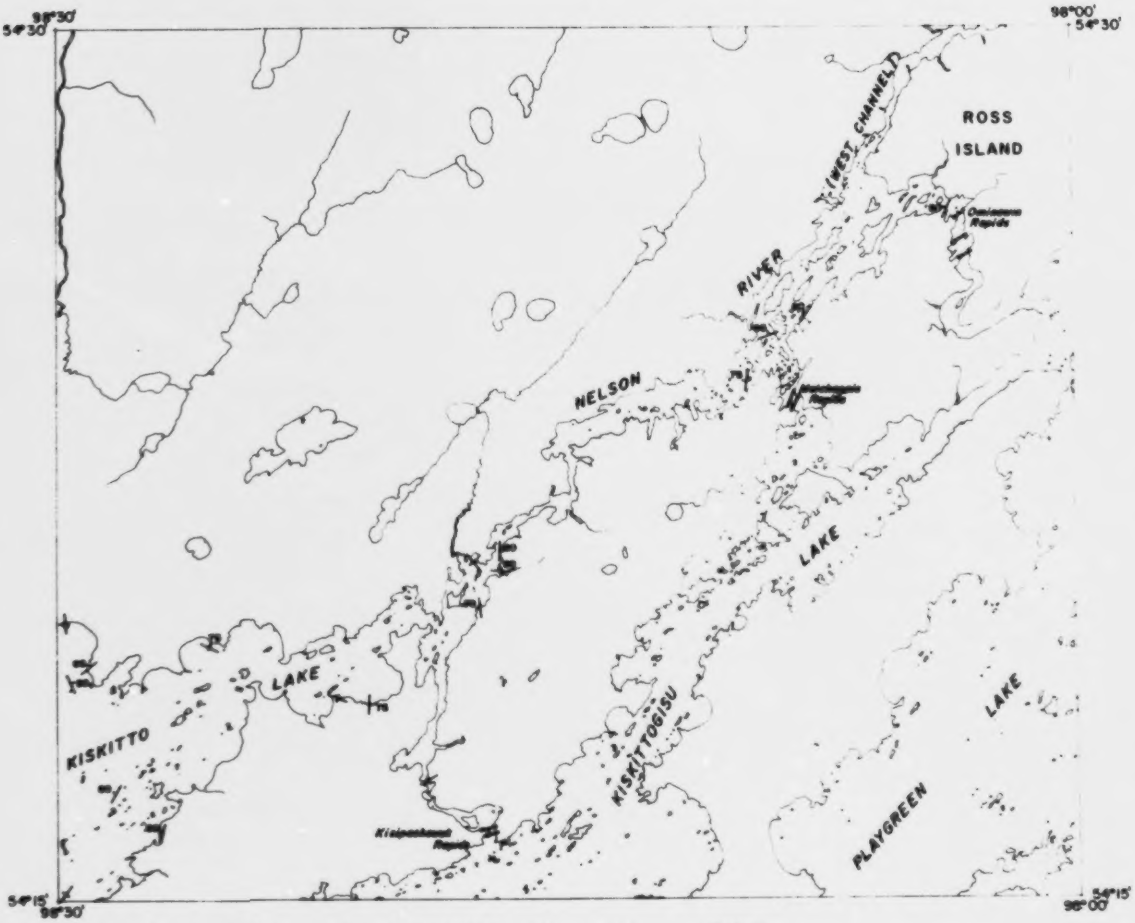
98°30'
54°30'
98°00'
54°30'
ROSS
ISLAND
(WEST CHANNEL)
RIVER
NELSON
LAKE
KISKITTO
LAKE
KISKITTOGISU
LAKE
PLAYGREEN
LAKE
Rapids
Rapids
Rapids
54°15'
98°30'
54°15'
98°00'

Figure I : Location and orientation of diabase dykes

Uralitization of the pyroxene is common; less abundant alteration products are magnetite and chlorite.

An example of hornblende diabase, 1.5 miles (2.5 km) north of Metchanais Rapids, shows the complete replacement of pyroxene by green amphibole and it is concluded that the hornblende diabase was derived by deuteric alteration of pyroxene diabase.

METAMORPHISM

Facies classification in the map-area is limited by lack of aluminum silicates and other reference minerals. However, high grade metamorphism, under upper amphibolite facies conditions, is demonstrated by the widespread anatexis and development of migmatites. This was followed by retrogression to conditions of the greenschist facies. Representative mineral assemblages in the gneisses (units 1-3) are listed in Table 2.

Table 2: Metamorphic mineral assemblages in the map-area

Map-unit	Mineral assemblages
1	Oligoclase-quartz-microcline-biotite-(carbonate, sericite, chlorite)
2	Plagioclase-quartz-biotite-microcline-(sericite, carbonate, hornblende, epidote, clinozoisite)
2a	Hornblende-andesine-biotite-quartz-(sphene, magnetite)
3	Hornblende-biotite-labradorite-(magnetite)
	Andesine-quartz-hornblende-biotite-(magnetite, apatite, carbonate)
	Andesine-quartz-microcline-biotite-(carbonate, sericite)
	Quartz-andesine-(biotite, carbonate, microcline)

STRUCTURE

The dominant topographic and magnetic lineaments in the map-area trend northeast, parallel to the trend of the major rock units. The foliation in these units similarly strikes northeast and appears to be largely cataclastic in origin. The flaser gneiss (1) exhibits the greatest degree of cataclasis and has a pronounced fissility, due to thin (1 mm), closely spaced, discontinuous layers of finely comminuted quartz and feldspar. The more mafic rocks, such as hornblende-biotite gneiss (3), have a strong mineral foliation (especially biotite), which is approximately parallel to the compositional layering. Felsic layers in the mafic gneisses possess a cataclastic foliation.

S and Z-shaped minor folds occur locally in map-units 1, 2 and 3. The axes of these folds plunge predominantly to the east or southeast at angles of 35 to 50 degrees.

Joints are common in all major rock units. The joints strike mainly northeast and northwest (Figure 2) and in some instances provided the sites for diabase injection (Figure 1).

The latest planar structures in the area are small faults which offset late pegmatite veins (5). Visible offset of pegmatite veins by these faults rarely exceeds 15 cm, and many of the small faults are themselves occupied by pegmatite veins. Late faults and shears strike mostly in a northeasterly direction and have steep to moderate dips; some are shown on the accompanying geological map. The apparent sense of movement on the faults shows no consistent pattern, and the faults are considered to represent minor readjustments following major deformation.

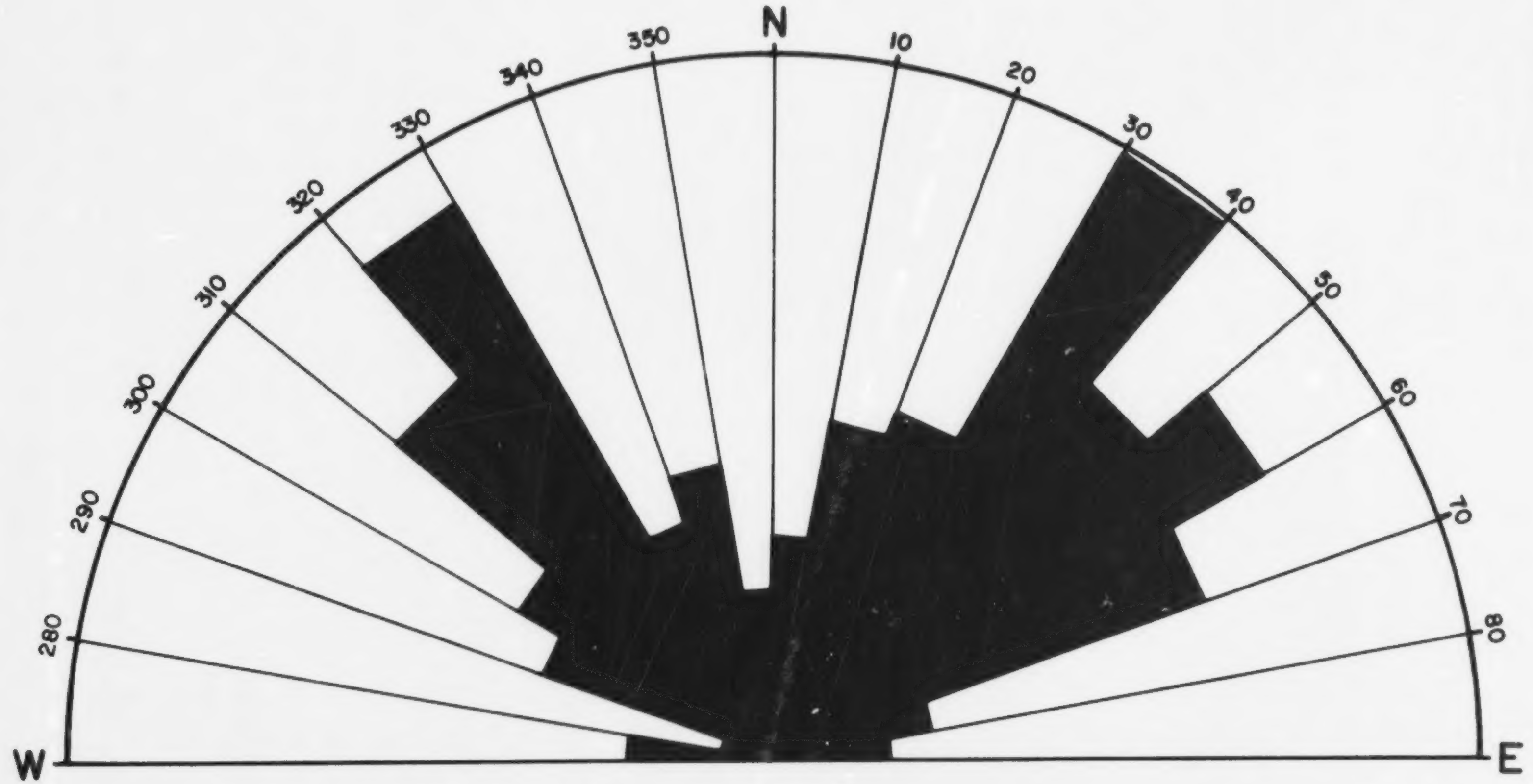

Figure 2: Strike frequency distribution of joints

The course of the Nelson River through the West Channel is controlled for the most part by a combination of foliation and jointing in the underlying bedrock. The southwest part of the channel, downstream from Kisipachewuk Rapids, is controlled by northwest-striking joints. Two miles (3 km) northwest of the rapids, the river channel adopts a northerly course, parallel to the foliation in a large mass of quartz monzonite (5) and the adjoining gneisses (3), and more or less along the contact between these two rock units. At the outlet of Kiskitto Lake, both the river channel and the foliation swing to the north-northeast. Further downstream, at a point five miles (8 km) due north of Kisipachewuk Rapids, the trend of the foliation becomes east-northeast, and is paralleled by late shearing. Four miles (6.5 km) downstream from Kiskitto Lake, the course of the West Channel swings sharply northward, controlled mostly by jointing and faulting which transects the foliation. Within a mile or so the river resumes its east-northeasterly direction, again parallel to the foliation in the underlying gneisses. The remaining part of the West Channel, as far as the map-boundary, follows the strong northeasterly cataclastic foliation in the flaser gneiss (1).

ECONOMIC GEOLOGY

Small gossans, apparently derived from oxidation of pyrite, were noted at two locations in the West Channel, northeast of Metchanais Rapids, and at six locations on Kiskitto Lake (Figure 3). Another gossan was observed on the shore of Kiskitto Lake, a few hundred metres south of the map-area. Twelve samples from eight of these nine gossans were assayed for copper, nickel, zinc and gold (Table 3). The results indicate that negligible amounts of these metals are present. A brief description of the gossan zones is also included in Table 3.

Table 3: Summary of gossan occurrences and assay results*

Location reference number (Figure 3)	Location	Map-unit	Description	Sample number	Weight (lbs.)	Lab number	Gold oz. per ton	Copper %	Nickel %	Zinc %
1	0.3 km northwest of Ominawin Rapids immediately south of Ross Island	1	Diabase dyke (1.8 m wide) in contact with pegmatite, shows fine pyrite along fracture planes	348	1/8	M5935	Nil	0.02	0.02	0.005
2	West shore of West Channel, 0.5 km south of Jenpeg road	3	Small patch of gossan, 1 m wide, in hornblende-biotite gneiss. The gneiss strikes 030 and dips 45°SE	410	1	M5936	0.02	0.03	Trace	Trace
				410A	1¼	M5937	Nil	0.05	Trace	Trace
3	North shore of Kiskitto Lake at outlet to West Channel	1	Several small gossans up to 1 m wide, in amphibolite lenses in hornblende-biotite flaser gneiss. Local malachite staining is present. The gneiss strikes 075 and dips 75°SE	331	1¾	M5932	Trace	0.10	Trace	0.005
				331A	2¼	M5933	Nil	0.185	0.01	0.02
				331C	1½	M5934	0.01	0.19	0.01	0.015
4	South shore of Kiskitto Lake at outlet to West Channel	3	Several small gossan patches in a remnant of hornblende-biotite gneiss in granite (5). The gneiss is cut by pegmatite, strikes 050 and dips 60°SE	310			not assayed			
5	Island in Kiskitto Lake 3.8 km west of West Channel	3	Minor gossans in inclusions of hornblende-biotite gneiss (3) in quartz monzonite (5)	165B	¾	M5931	Trace	0.018	Trace	Trace
6	South shore of Kiskitto Lake 5 km west of outlet to West Channel	3	Small patches of gossan in lenses of hornblende-biotite gneiss intruded by quartz monzonite. The gneiss strikes 050 and dips vertically	160B	4¼	M5930	Nil	0.04	Trace	0.02
7	South shore of Kiskitto Lake, 5.5 km west of outlet to West Channel	2	3 m wide gossan zone, exposed for about 40 m along strike before passing under the lake. The host rocks are tonalitic (2) and hornblende-biotite gneisses (3), intruded by abundant pegmatitic granite	141S	2¼	M5927	Nil	0.01	0.005	0.01
				141N	2	M5928	Nil	0.065	Trace	0.005
8	South shore Kiskitto Lake, 6 km west of outlet to West Channel	2	Small gossan in tonalitic gneiss (2), intruded by pegmatitic granite (5)	142	1¾	M5929	Nil	0.012	Trace	0.005
9	South shore Kiskitto Lake 300 m south of map-boundary	3	1.8 m wide gossan zone in hornblende-biotite gneiss, striking 080 and dipping 70°S, cut by minor diabase and pegmatite dykes	135	2	M5926	Nil	0.008	0.005	0.01

* [illegible] the Manitoba Mines Branch Analytical Laboratory, Winnipeg

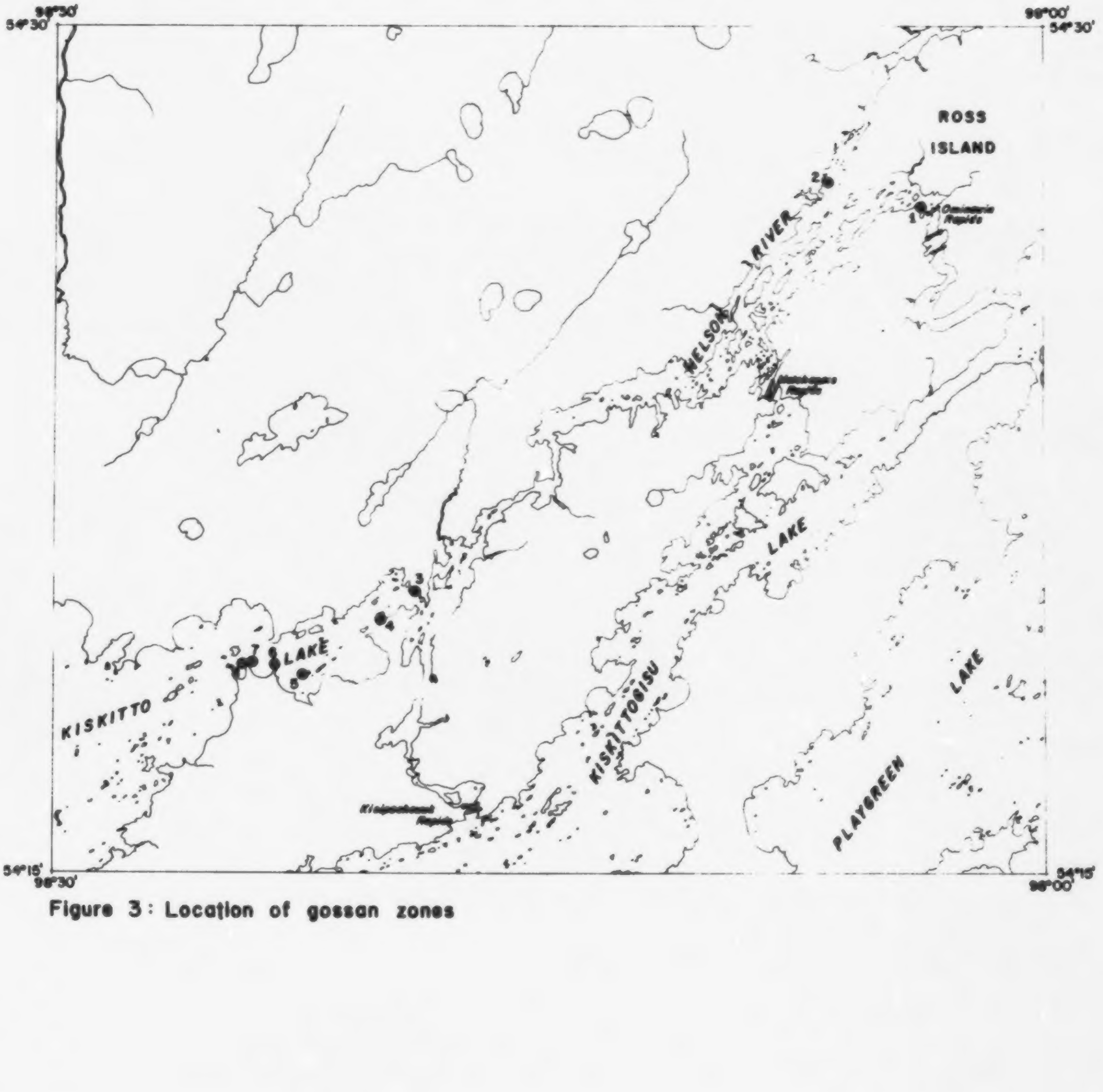
98°30'
54°30'
98°00'
54°30'
ROSS
ISLAND
2
1
NELSON
RIVER
3
4
6
7
8
LAKE
5
KISKITTO
KISKITTOGISU
LAKE
PLAYGREEN
LAKE
54°15'
98°30'
54°15'
98°00'

Figure 3: Location of gossan zones

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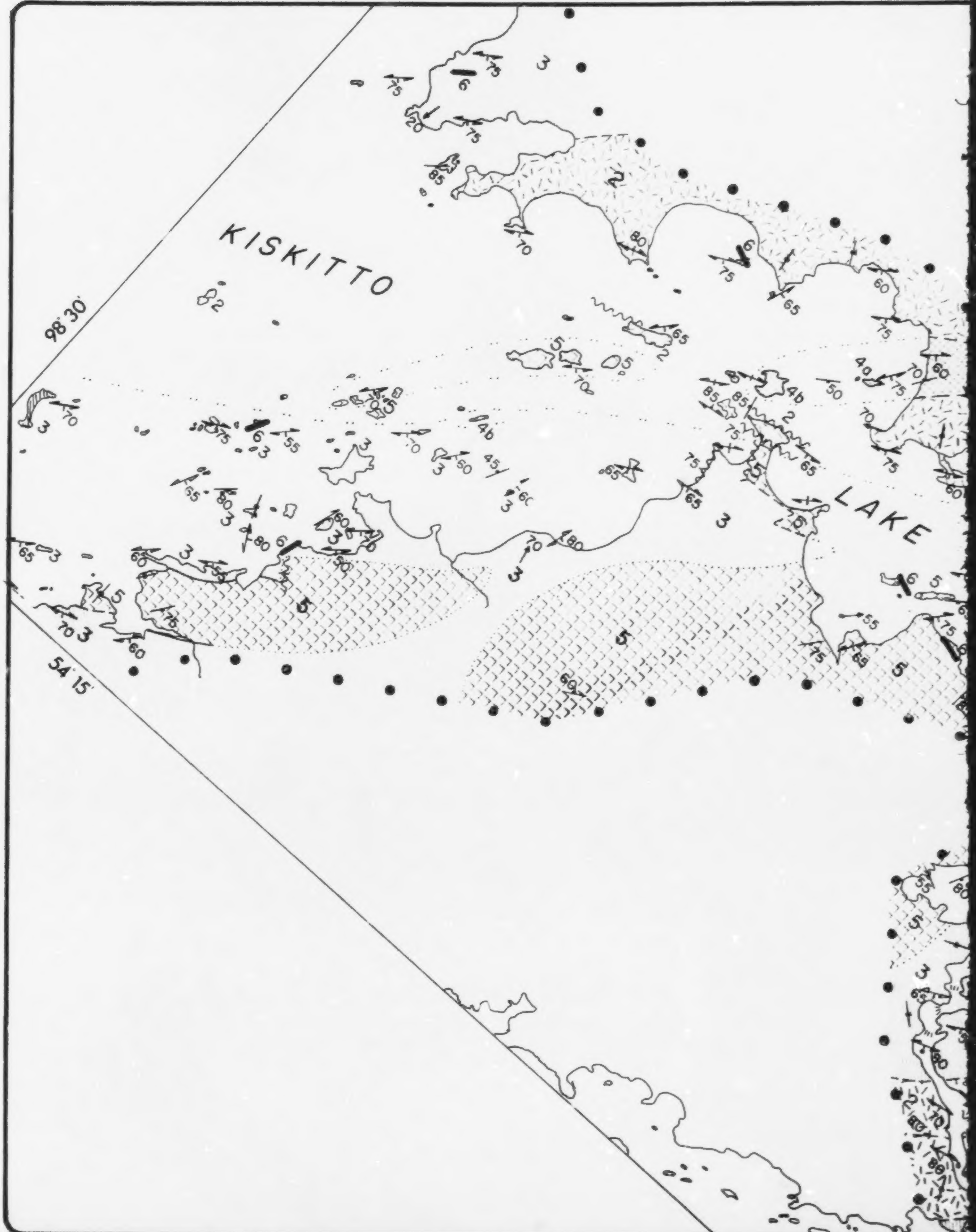
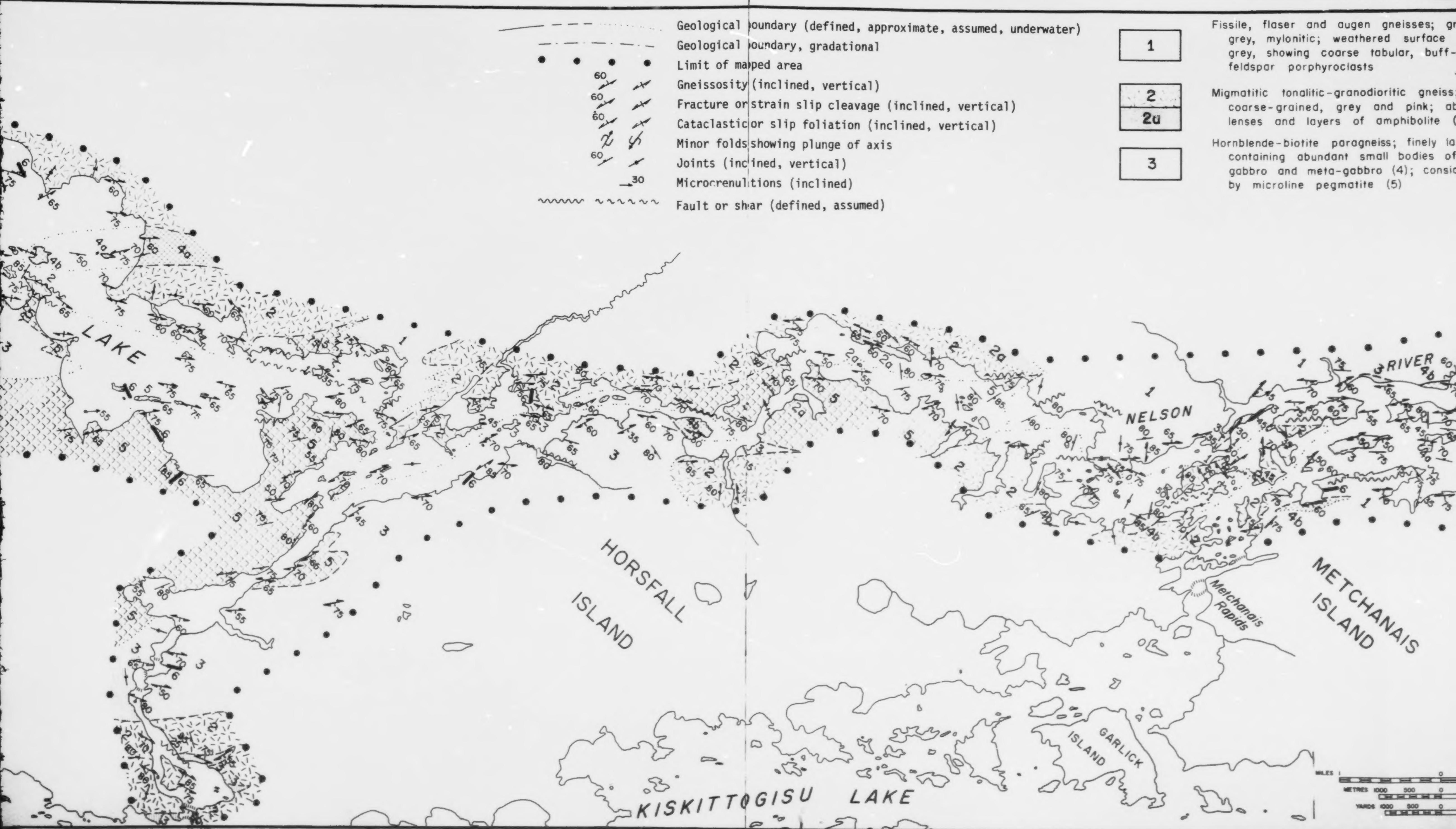
1962: Cross Lake map-area, Manitoba; Geol. Surv. Can., Paper 61-22.

Rousell, D.H.
1965: Geology of the Cross Lake area; Man. Mines Br., Publ. 62-4.


KISKITTO
LAKE
98°30'
54°15'


Geological boundary (defined, approximate, assumed, underwater)
Geological boundary, gradational
Limit of mapped area
Gneissosity (inclined, vertical)
Fracture or strain slip cleavage (inclined, vertical)
Cataclastic or slip foliation (inclined, vertical)
Minor folds showing plunge of axis
Joints (inclined, vertical)
Microcrenulations (inclined)
Fault or shear (defined, assumed)
1
2
2a
3
LAKE
NELSON
RIVER
HORSFALL
ISLAND
METCHANAIS
ISLAND
Metchanais
Rapids
GARLICK
ISLAND
KISKITTOGISU LAKE
MILES
METRES 1000 500 0
YARDS 1000 500 0

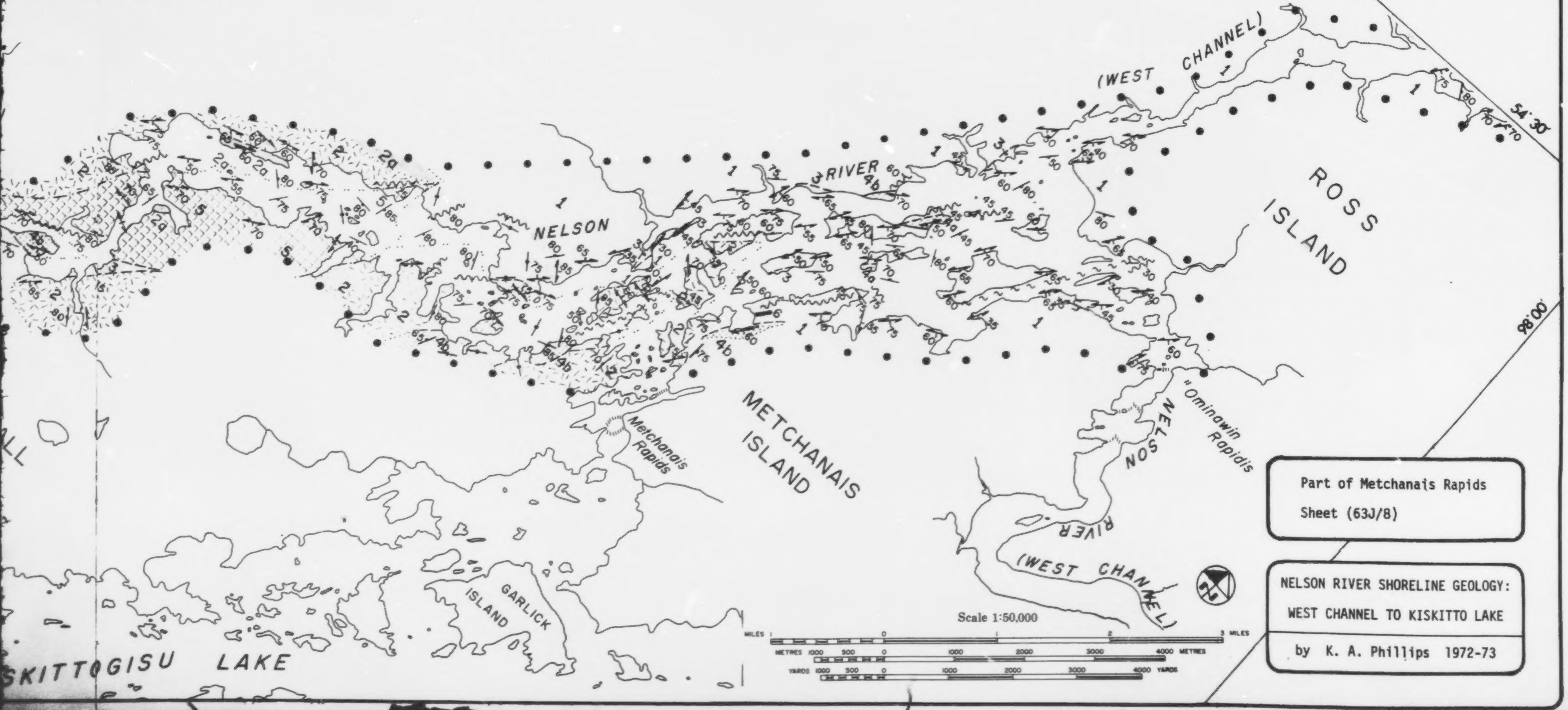
Fissile, flaser and augen gneisses; gr
grey, mylonitic; weathered surface
grey, showing coarse tabular, buff-
feldspar porphyroclasts

Migmatitic tonalitic-granodioritic gneiss
coarse-grained, grey and pink; ab
lenses and layers of amphibolite (

Hornblende-biotite paragneiss; finely la
containing abundant small bodies of
gabbro and meta-gabbro (4); consid
by microline pegmatite (5)

Geological boundary (defined, approximate, assumed, underwater)
Geological boundary, gradational
Limit of mapped area
Gneissosity (inclined, vertical)
Fracture or strain slip cleavage (inclined, vertical)
Cataclastic or slip foliation (inclined, vertical)
Minor folds showing plunge of axis
Joints (inclined, vertical)
Microcrenulations (inclined)
Fault or shear (defined, assumed)

1	Fissile, flaser and augen gneisses; groundmass dark grey, mylonitic; weathered surface uniformly pale grey, showing coarse tabular, buff-coloured feldspar porphyroclasts
2 2a	Migmatitic tonalitic-granodioritic gneiss; medium to coarse-grained, grey and pink; abundant small lenses and layers of amphibolite (2a)
3	Hornblende-biotite paragneiss; finely layered and containing abundant small bodies of pegmatitic gabbro and meta-gabbro (4); considerably intruded by microline pegmatite (5)
4	Gabbro, minor norite, altered derivatives; coarse to medium-grained, massive to slightly foliated 4a Norite, pyroxene gabbro 4b Hornblende gabbro, and pegmatitic gabbro
5	Quartz monzonite to biotite granite and granodiorite; coarse-grained, commonly pink and pegmatitic
6	Diabase


NELSON RIVER
(WEST CHANNEL)
ROSS ISLAND
METCHANAIS ISLAND
Metchanais Rapids
"Ominawin Rapidis
NELSON RIVER
(WEST CHANNEL)
GARLICK ISLAND
SKITTOGISU LAKE
54°30'
98°00'
Scale 1:50,000
MILES 1 0 2 3 MILES
METRES 1000 500 0 1000 2000 3000 4000 METRES
YARDS 1000 500 0 1000 2000 3000 4000 YARDS

Part of Metchanais Rapids Sheet (63J/8)

NELSON RIVER SHORELINE GEOLOGY: WEST CHANNEL TO KISKITTO LAKE

by K. A. Phillips 1972-73

APPENDIX 3 - I

GEOLOGY OF THE OSPWAGAN LAKE (EAST HALF) AREA

GEOLOGY OF THE OSPWAGAN LAKE (EAST HALF) AREA

by

J. F. STEPHENSON
Mines Branch
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba
July, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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MAP

Ospwagan Lake (East half) (in pocket)

INTRODUCTION

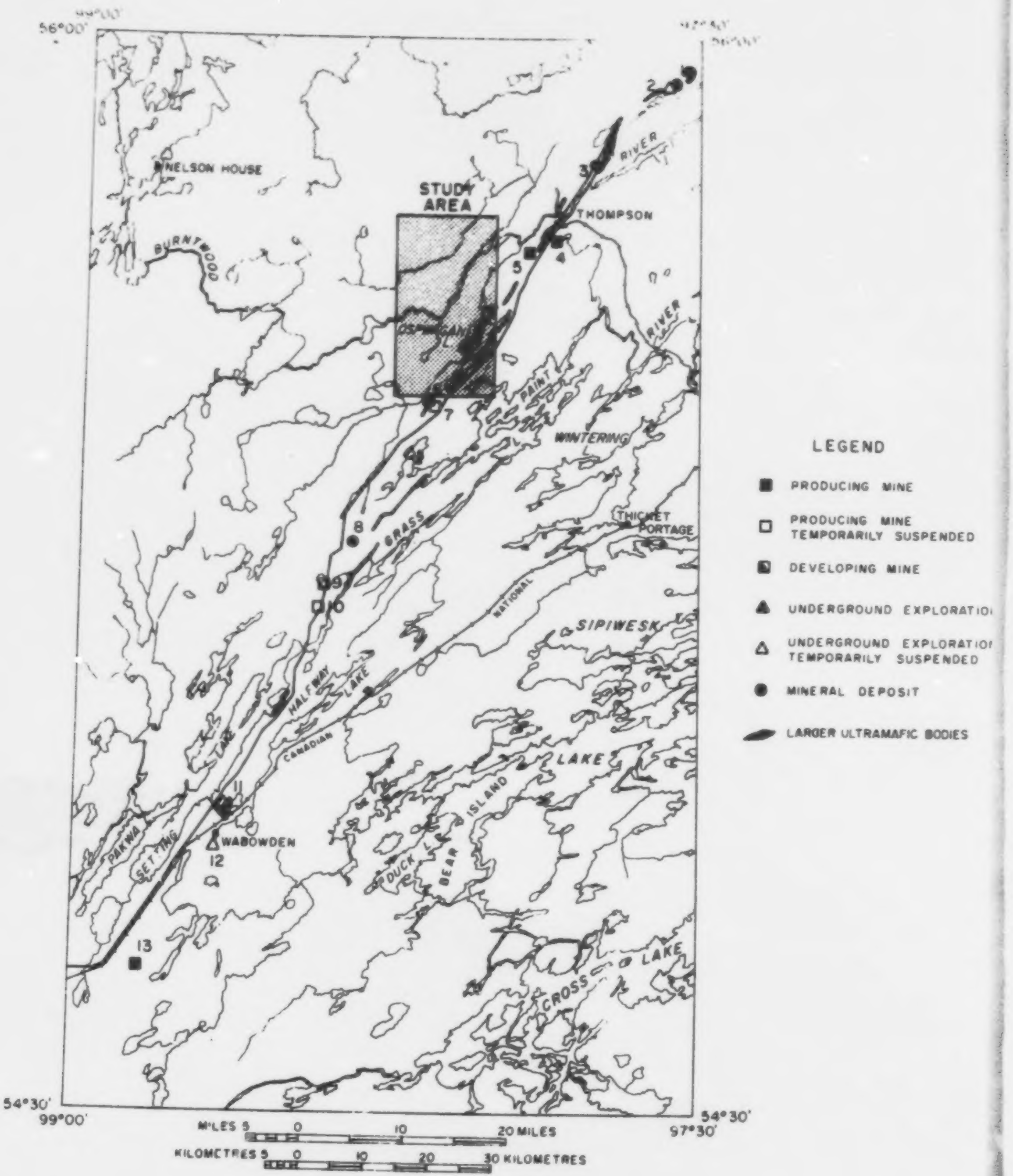
Location and access

The Ospwagan (Pipe) Lake area comprises 173 square miles (450 square km) bounded by longitudes 98°00' and 98°15' and latitudes 55°30' and 55°45' (sheet 63O-9 (East half) of the National Topographic Series). The 20th Base Line passes approximately through the middle of the area, which lies 14 miles (22 km) southwest of Thompson (Figure 1). Provincial Road 391 to Thompson crosses the southeast corner of the map-area and provides direct access to Lower and Upper Ospwagan Lakes, Paint and Mid Lakes. Daily air service is maintained between Thompson and Winnipeg.

The Burntwood, Taylor and Manasan Rivers are all navigable by canoe. Between Opegano Lake (just west of the map-area) and Birch Tree Lake, three portages must be negotiated on the Burntwood River at Jackpine Falls (350 m), Upper Kepuche Rapids (100 m) and Kepuche Falls (300 m). A fourth portage, 200 m in length, and the last before Thompson, bypasses Manasan Falls just east of the map-area. The portages are all located on the south bank of the river and are well preserved through regular use.

Birch Tree Brook, a narrow meandering tributary of the Burntwood River, can be navigated with difficulty where it crosses the map-area.

The original canoe route between Thicket Portage, at Mile 185 on the Hudson Bay Railway, and Nelson House, crossed the map-area by way of Ospwagan Lake and the Burntwood River. This route has been described by Alcock (1921a):



99°00'
56°00'
97°30'
56°00'
NELSON HOUSE
BURNTWOOD
STUDY AREA
OSPWAGAN L.
THOMPSON
RIVER
RIVER
PAINT
WINTERING
THICKET PORTAGE
GRASS
NATIONAL
SIPIWESK
HALFWAY LAKE
CANADIAN
LAKE
ISLAND
DUCK L.
BEAR
PAKWA
SETTING
LAKE
WABOWDEN
CROSS
LAKE
1
2
3
4
5
6
7
8
9
10
11
12
13
54°30'
99°00'
54°30'
97°30'
MILES 5 0 10 20 MILES
KILOMETRES 5 0 10 20 30 KILOMETRES
LEGEND
PRODUCING MINE
PRODUCING MINE TEMPORARILY SUSPENDED
DEVELOPING MINE
UNDERGROUND EXPLORATIO
UNDERGROUND EXPLORATIO TEMPORARILY SUSPENDED
MINERAL DEPOSIT
LARGER ULTRAMAFIC BODIES

FIGURE 1. Location of map-area in relation to nickel mines and deposits in the Manitoba nickel belt. (1)(2) Moak Lake; (3) Mystery Lake; (4) Thompson; (5) Birch Tree; (6) Pipe #2; (7) Pipe #1; (8) Hambone Maralgo; (9) Soab North; (10) Soab South; (11) Bowden Lake; (12) Bucko Lake; (13) Manibridge.

(1-10)	International Nickel Company of Canada, Limited
(11-12)	Bowden Lake Nickel Mines, Limited
(13)	Falconbridge Nickel Mines Limited

> "From Thicket Portage a canoe route leads direct to Ospwagan Lake. The first part consists of about 15 miles on Wintering Lake around a long point which stretches northeastward into the lake. A winding creek which enters Wintering Lake from the west is then ascended to the first portage. This portage has a length of 53 chains and leads to a small narrow lake extending in a northeast direction. From the northwest side of this lake a portage 1 mile and 13 chains in length leads to Paint Lake, an expansion of Grass River. The route crosses Paint Lake between a number of islands to a bay on its northwest shore. A short portage of 8 chains leads over a clay bank to a small lake, and from the opposite side of this lake the second long portage on the route begins. This has a length of 1 mile and 10 chains and leads to another small lake Mid Lake. A fifth portage with a length of 30 chains reaches Ospwagan Lake."

From Ospwagan Lake the Burntwood River can be reached via the Manasan River or by taking a 2.5 mile (4 km) portage across wet muskeg to Wapishtigau Brook, a tributary of the major waterway.

Physical features and drainage

Topographic relief in the area is monotonously low except for two 115 feet (35 m) high flat-topped hills in the northwest, and rock outcrops rising to a height of 100 feet (30 m) along the west shores of Upper and Lower Ospwagan Lakes. Maximum relief in the area is about 360 feet (109 m). One of the hills immediately north of Birch Tree Brook attains a maximum height for the area of 965 feet (294 m) above mean sea level. South of Birch Tree Brook the elevation is all below 850 feet (260 m). The lowest areas are occupied by the Manasan River and Ospwagan Lake which have elevations of about 600 feet (185 m). The Burntwood River descends via three sets of rapids, from an elevation of 670 feet (305 m) on Opegano Lake to 625 feet (190 m) on Birch Tree Lake.

Most of the area consists of low wet muskeg, pierced by a few small outcrop knolls. Exposed bedrock amounts for less than 1 per cent of the area, and is largely confined to lake and river shorelines. The main drainage direction is to the northeast, via the Burntwood River, which flows through the centre of the region. Two tributaries, Wapishtigau and Birch Tree Brooks, drain swampy areas south and north of the river respectively. The Taylor River-Ospwagan Lake-Manasan River system drains the southeastern section, and enters the Burntwood River just below Manasan Falls.

Manitoba Hydro's proposed control dam at Manasan Falls will impound water upstream on the Burntwood River. At the time of writing it is thought that the Manasan forebay will have an elevation of 690 feet (210 m). This would have the effect of submerging all of the outcrops along the river within the map-area.

Upper Ospwagan Lake drains into Lower Ospwagan Lake via a short stretch of the Taylor River. The meagre flow into Upper Ospwagan Lake must account for the unusual clarity of the water, a fact noted by Tyrrell (1902, page 32F) in 1896:

> "The water is clear and transparent, very different from the muddy water of all the surrounding lakes and streams".

Upper Ospwagan Lake was used by The International Nickel Company of Canada, Limited as a receptacle for overburden stripped from the Pipe Lake Mine. During the overburden disposal operation, the level of the lake was raised, and its flow into the Taylor River was restricted (to prevent contamination) by means of a dam at the north end of the lake. The dam has now been removed and the lake returned to its former level.

History and previous work

The first white men in the Ospwagan Lake area were probably fur traders travelling the regular canoe route between Thicket Portage and Nelson House. Henry Kelsey, in 1691, may have ascended the Burntwood River some 71 miles from its mouth at Split Lake (Alcock, 1921b), which would have brought him close to the site of the present city of Thompson. A brief history of the fur trade west of Hudson Bay is given by Alcock (1921b):

> "The Canadian traders from Montreal were the first into the Burntwood River country. Their route was down the Nelson River from Lake Winnipeg to Sipiwesk Lake, over Cross Portage into Landing Lake, and thence across Thicket Portage to Wintering Lake, from which it was easy to reach the Burntwood along the route which is still the one used today.
>
> In 1793 the Burntwood was ascended by a Hudson's Bay Company's surveyor. On September 5, 1792, David Thompson left York Factory, and ascended Nelson River as far as Sipiwesk Lake. Here he built a post and passed the winter. In the spring he traversed Cross Portage, surveyed Landing Lake and entered Wintering Lake, then known as Chatham Lake. Here on a long point extending northward into the lake the company had a trading post known as Chatham House. From Chatham House Thompson carried his survey across Paint and Ospwagan (Pipe) Lakes and up the Burntwood to Duck Portage, where he crossed over into the Churchill River waters. He ascended the Churchill for a distance of 33 miles, returning down the Burntwood to Split Lake, and from there down the Nelson to York Factory. His notes give a minute description of the routes, with lengths of portages, what rapids can be run, and many other details. Thompson altogether spent six years in the general region of Burntwood and Grass Rivers; during four of these, 1792-1796, he was in the service of the Hudson's Bay Company; the other two, 1804-1806, were spent in the employ of the North-West Company. In 1814 Thompson compiled his various surveys into a map of the Northwest Territories, the original of which is now in the Crown Lands Office, Toronto. This served as a basis for all the general maps of the region until the work of Tyrrell and Dowling, performed in 1896 and 1899, was published.
>
> In the summer of 1896 J. B. Tyrrell made a survey of the lower part of the Burntwood River. The route followed was from Sipiwesk Lake on the Nelson, across Landing, Wintering, Paint, and Ospwagan Lakes and up the Burntwood to Nelson House."

Tyrrell (1902) believed that the greenstones, exposed on Ospwagan Lake, formed a northeasterly trending synclinal trough of Huronian schist surrounded by Laurentian gneiss. He reported on the garnetiferous gneisses and whitish gneissic granite along the Burntwood River above Manasan Falls, and noted the shallow dip of these rocks in the vicinity of Upper Kepuche Falls. Interestingly enough, he mentioned the erratic behaviour of his magnetic compass from Cross Portage to Ospwagan Lake, but without speculating as to its cause.

McInnes (1913) travelled up the Burntwood River in 1906 and was the first to report the occurrence of volcanic rocks on Ospwagan Lake, although Tyrrell may have implied their existence from his 'Huronian schists'.

Alcock (1921a) conducted a more thorough investigation of the area and produced a geological map. Like McInnes, he noted that the greenstones represented "basic volcanic flows", and further recognized thinly banded, dense black rocks as being basic tuffs.

It was not until the publication of Quinn's (1955) map of the Nelson House area, at a scale of 1 inch to 4 miles, that two important features within the southwestern portion of his map-area were presented. His map showed the existence of ultramafic rocks on Setting and Ospwagan Lakes and the presence of a set of major interlacing faults trending northeast through this region. Quinn also proposed, on the basis of flow and pillow top determinations, that the volcanic rocks on Ospwagan Lake formed a northeasterly trending syncline, and that the volcanic rocks conformably overlie most of the sediments. These rocks were correlated with similar rocks on Assean Lake which Dawson (1941) had previously named the Assean Lake Series.

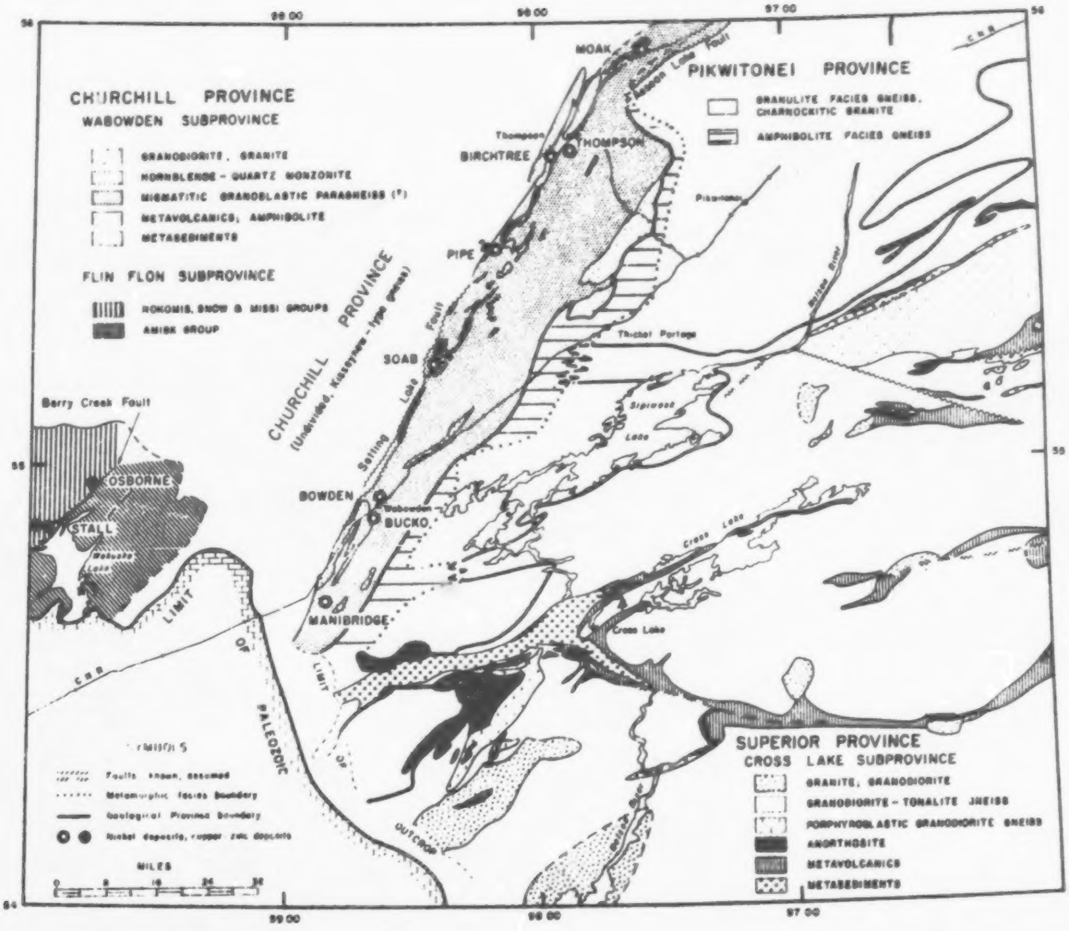
The geology of the Thompson-Moak Lake district was described by Patterson (1963) and discussed by Davies (1960) following the recognition of the area's considerable economic importance. At this time the low-grade nickel orebody at Moak Lake and the higher-grade orebody at Thompson (Figure 1) had been discovered. The latter was expected to produce 75 million pounds of nickel annually. Davies noted that the "long narrow zone of intense deformation" in which the nickel deposits and associated ultramafic rocks are located, coincides with a gravity "low" defined by Wilson and Brisbin (1961). This negative Bouguer gravity anomaly lies northwest of, and parallel to a linear gravity "high" first described by Innes (1960) as the "Nelson River high". This "high" anomaly lies along the Nelson River valley and follows, in arcuate form, the belt of high grade gneisses and granulites southwest of the nickel belt. Wilson and Brisbin (1961), in their discussion of the regional structure of the Thompson-Moak Lake area, postulated that the nickel belt is the remnant root of a mountain range of island arc or alpine-type, with thrusting of the southeast side toward the northwest. The regional gravity anomalies, defined by Wilson and Brisbin (op. cit.) were explained by down buckling of a two-layer crust below the nickel belt to account for the negative gravity strip, accompanied by upwarping of mantle material on either side to produce the flanking positive gravity anomalies. The zone of gravity disturbance was considered to coincide with the boundary between the Churchill and Superior blocks of the Precambrian Shield.

Controversy surrounds the exact positioning of the junction between the Churchill and Superior provinces, particularly with regard to its northeastward continuation beyond the nickel belt. Stockwell (1961) favoured locating the contact between the easterly trending high grade Nelson River gneisses and granulites to the southeast, and the northeasterly trending medium grade gneisses to the northwest. Kornik and MacLaren (1966) placed the junction along a northeasterly trending "long, continuous magnetic low" which truncates the easterly trending magnetic pattern to the southeast. Bell (1966) considered the boundary to lie on the northwestern contact of the belt of amphibolite facies gneisses and granulites. These geologists essentially agreed on the position of the boundary in the Moak-Setting Lakes region.

The views expressed by various workers on the Churchill-Superior boundary problem from 1939 to 1970 are reviewed by Bell (1971a), and a synthesis of "boundary" geology, based on the correlation of geological, geophysical and geochronological data, is presented in a second paper by Bell (1971b). In the latter paper, Bell formulates his concept of the junction between the Churchill and Superior structural provinces (Figure 2):

> "The Precambrian Shield in Central Manitoba is the product of crustal plate growth by stratigraphic piling, with synorogenic plate adjustment through large displacement along transverse, transcurrent and normal faults. The geology does not support Archean or Aphebian shield accretion by continental drift, in sensu stricto."

According to Bell (1971b) the belt of granulite and amphibolite facies gneisses, separating the Churchill and Superior provinces, are an inlier of early Precambrian (Archean) rocks comprising the Pikwitonei geological province. Rocks northwest of this zone are included in the Churchill geological province. In the boundary region these rocks have been subdivided by Bell into the Wabowden subprovince, comprising "migmatized paragneisses of the Thompson belt", together with sedimentary and intercalated volcanic rocks, and nickel-bearing ultramafic intrusions.


99 00
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CHURCHILL PROVINCE
WABOWDEN SUBPROVINCE
GRANODIORITE, GRANITE
HORNBLENDE - QUARTZ MONZONITE
MIGMATITIC GRANOBLASTIC PARAGNEISS (?)
METAVOLCANICS, AMPHIBOLITE
METASEDIMENTS
FLIN FLON SUBPROVINCE
NOKOMIS, SNOW & MISSI GROUPS
AMISK GROUP
PIKWITONEI PROVINCE
GRANULITE FACIES GNEISS, CHARNOCKITIC GRANITE
AMPHIBOLITE FACIES GNEISS
MOAK
Thompson
BIRCHTREE
THOMPSON
PIPE
SOAB
BOWDEN
Wabowden
BUCKO
MANIBRIDGE
OSBORNE
STALL
Berry Creek Fault
Setting Lake Fault
CHURCHILL PROVINCE
(Undivided, Kisseynew - type gneiss)
Pikwitonei
Thicket Portage
Sipiwesk Lake
Cross Lake
C N R
LIMIT OF PALEOZOIC OUTCROP
SYMBOLS
Faults known, assumed
Metamorphic facies boundary
Geological Province boundary
Nickel deposits, copper zinc deposits
MILES
0
8
16
24
32
SUPERIOR PROVINCE
CROSS LAKE SUBPROVINCE
GRANITE, GRANODIORITE
GRANODIORITE - TONALITE GNEISS
PORPHYROBLASTIC GRANODIORITE GNEISS
ANORTHOSITE
METAVOLCANICS
METASEDIMENTS

FIGURE 2. Geological map of the Upper Nelson River area, Manitoba (after Bell, 1971b).

The Wabowden subprovince, as defined by Bell (1971b), exactly encompasses the area informally termed the 'Moak-Setting Lakes belt', 'Manitoba nickel belt' or 'Thompson nickel belt'. It has well defined aeromagnetic lineaments which correspond to the major northeasterly striking faults (Kornik, 1967, 1971). To the northwest, the Churchill Province consists of garnetiferous gneisses and granitic rocks, which are similar to the Kisseynew paragneisses of the Snow Lake-Sherridon region.

A compilation map of the Moak-Setting Lakes area with accompanying guide books (Quirke et al., 1970, and Coats et al., 1972) has been produced by officers of The International Nickel Company of Canada, Limited, Manitoba Department of Mines, Resources and Environmental Management, Falconbridge Nickel Mines Ltd., and the Geological Survey of Canada. This is the most recent version of the regional geology of the Manitoba nickel belt and was extremely helpful in the present work.

Present work and acknowledgements

This work was undertaken in order to obtain as much bedrock geological information in the area as possible, prior to the inundation of shoreline outcrops as a result of Manitoba Hydro's Churchill River Diversion scheme. This project forms part of current investigations of the Churchill and Nelson River basins, sponsored by the Lake Winnipeg, Churchill and Nelson Rivers Study Board. The writer would like to acknowledge the full financial support given by the Study Board which made this project possible. In addition logistical support was provided, in part, by the Study Board's field coordinator, D. C. Windsor.

Field work was undertaken by one 2-man party over a 2-month period during the summer of 1972. Most of the outcrops on the lakes and rivers were reached by boat. Inland traverses were conducted to known outcrop locations in the southern part of the map-area. Less accessible exposures, especially in the northern part of the area, were visited by helicopter.

Vertical aerial photographs (obtained from the National Air Photo Library, Ottawa) at a scale of one-quarter mile to one inch, were used in the field. Field data were plotted on a base map at a scale of one-half mile to one inch, enlarged from a one mile to one inch map prepared by the Surveys and Mapping Branch, Department of Mines and Technical Surveys, Ottawa. The final geological map, prepared by the Draughting Section of the Manitoba Mines Branch, is published at a scale of 1:50,000.

The writer was ably assisted in the field by G. Wallace. He would also like to acknowledge the useful discussions held with members of the geological staff of The International Nickel Company of Canada, Limited, in particular the company's Staff Geologist, R. Worsfold.

Chemical analyses of the metavolcanic and ultramafic rocks were carried out by A. MacKay and staff of the Manitoba Mines Branch Analytical Laboratory.

Finally, the writer would like to express his thanks to Ian Haugh for his critical comments and helpful advice in the preparation of this report.

GENERAL GEOLOGY

Introduction

All consolidated rocks within the Ospwagan Lake area are Precambrian in age and belong to the Churchill province as defined by Rance (1966). The map-area is located between important nickel-producing mines (Figure 1), and straddles the geological boundary between cataclastically deformed, northeast-trending, lit-par-lit gneisses and greenstones to the southeast (comprising Bell's (1971b) 'Wabowden subprovince' of the Churchill province), and garnetiferous paragneisses and gneissic granodiorites to the northwest (comprising Bell's (op. cit.) 'undivided Churchill province'). These two geologically and structurally distinct regions correspond respectively to subareas A and B in the present work (Table 1; see also the geological map accompanying this report).

The Ospwagan Lake portion of the Wabowden subprovince lies midway between Setting and Moak Lakes. All the economically important ultramafic bodies, with associated nickel sulphide deposits, occur within the Wabowden subprovince (Figure 1), and it is known from geophysical and drill core data, that one of the largest ultramafic bodies underlies Ospwagan Lake (Quirke *et al.*, 1970). The map-area also includes the best exposed of three known occurrences of recognizable extrusive rocks along the nickel belt, the others being on Setting and Assean Lakes.

The metavolcanic rocks are interlayered with northeast-striking metasediments, which are partially enveloped and possibly underlain by medium-grained, grey, lit-par-lit and porphyroblastic biotite gneisses. Broad zones of cataclastic rocks (originally mapped as metasediments

Table 1. Table of Formations

PLEISTOCENE			Glacio-lacustrine varved clays and silts Moraine deposits: boulder, gravel and sand	
			UNCONFORMITY	
PRECAMBRIAN	SUBAREA B Churchill Province (undivided)	B4	Diabase dykes (Mackenzie Swarm)	
			INTRUSIVE CONTACT	
		B3	Gneissic hornblende-quartz monzonite	Intrusive and/or anatectic rocks
		B2	Gneissic biotite-quartz monzonite and granodiorite	
		B1	Grey garnetiferous biotite (-cordierite-sillimanite) paragneiss	
			FAULT CONTACT	
	SUBAREA A Wabowden Sub-province	A9	a) Quartzo-feldspathic mylonite gneiss b) Blastomylonite c) Mylonite	Cataclastic fault zones
		A8	Granite pegmatite and aplite	Intrusive rocks
		A7	a) Serpentinite and serpentinized peridotite b) Clinopyroxenite	
		A6	a) Amphibolite b) Orthopyroxene-garnet gneiss	
		A5	Meta-arkose and feldspathic quartzite	
		A4	a) Meta-greywacke b) Mafic laminated tuff	
		A3	Pillowed meta-basalts	
		A2	a) Porphyritic meta-picrite b) Meta-picrite flow breccia	
		A1	Grey lit-par-lit and porphyroblastic gneiss	

by Quinn, 1955), derived principally from these gneisses, border the metasedimentary and metavolcanic rocks. These tectonites were partially or wholly recrystallized at the time of deformation to produce mylonite gneisses, blastomylonites and subordinate mylonites. Cataclastic fault zones, similarly mistaken as metasediments forming the northeastern continuation of the nickel belt fault system, were recognized by Haugh (1969) in the Split Lake area. These zones of steep, southeast-dipping and drag folded mylonitic rocks have been mapped as a separate unit in the Ospwagan Lake area, although everywhere they are gradational into less deformed rocks.

The metasedimentary and metavolcanic rocks have been subdivided according to lithological and compositional differences. Meta-arkoses and quartzites have been separated from meta-greywackes and laminated basic tuffs. A porphyritic meta-picrite, considered to be mainly effusive in origin, and a meta-picrite flow breccia have been recognized. These are both petrographically and chemically distinct from the pillowed meta-basalts.

Ultramafic rocks, consisting mainly of serpentinite, are poorly exposed in the area. They are considered to be slightly younger (due to the retention of primary textures and fabrics), but consanguineous with the picrite-basalt-producing tholeiitic magma. Lenses and sill-like bodies of amphibolite which occur within the gneisses, and which are boudinaged in the cataclastic zones, appear to represent metamorphosed igneous rocks.

Pegmatite stocks and dykes of various ages have intruded the supracrustal rocks and represent the final phase of igneous activity in the area.

Within the Churchill province, grey garnetiferous biotite paragneiss is the dominant rock type. The gneiss, which is commonly migmatitic and cordierite and sillimanite-bearing, is quite distinct in mineralogy and appearance from the Wabowden subprovince gneisses, and is continuous with the Kisseynew gneisses to the west. The gneiss surrounds massive or weakly foliated, and locally skialithic, granodiorite domes, considered to be anatectic derivatives of the paragneisses.

Northwest-striking mafic dykes, belonging to the Mackenzie dyke swarm, cut the northeast corner of the map-area.

Pleistocene varved clays and silts occur throughout most of the map-area. Moraine deposits, encircled by raised beaches, form prominent flat-topped hills in the northern part of the study area.

Subarea A - Wabowden subprovince

Subarea A occupies approximately one-fifth of the total map-area. It has been divided into nine main units (A1-A9) comprising gneisses, migmatites and derived mylonitic gneisses, and various metasediments, metavolcanics and ultramafic intrusive rocks. All units have a predominantly northeasterly strike and generally dip steeply to the southeast. Apart from good shoreline exposure on the lakes and islands, outcrops are sparse and the locations of contacts between the main units are consequently approximate or have been assumed.

Grey *lit-par-lit* and porphyroblastic gneiss (A1)

This unit, comprising a variety of migmatites, forms a major portion of subarea A, and corresponds to map-unit 7 on the regional map of the nickel belt (Coats *et al.*, 1972). *Lit-par-lit* and porphyroblastic gneisses are well exposed along the southeast shores of Upper and Lower Ospwagan Lakes, Mid, Middle and Paint Lakes, and comprise the few existing outcrops on and alongside Provincial Road 391. Although the main portion of this unit occurs southeast of Ospwagan Lake, a band of these gneisses outcrops intermittently along the west shore of Ospwagan Lake, and at points near the south and east boundaries of the map-area on the Taylor and Manasan Rivers respectively.

The proportion of mobilizate in these rocks ranges between 20 and 50 per cent. The restite layers consist of light to medium grey, and rarely dark grey, fine to medium-grained, foliated plagioclase-quartz-biotite rock, with or without potassium feldspar. These layers alternate with light grey or pale pink to white, coarser grained quartzo-feldspathic mobilizate. Red, pinhead-sized garnets occur locally. The restite layers range from several centimetres to several tens of centimetres in thickness and are separated by concordant streaks and lits of granitic mobilizate commonly showing pinch-and-swell structure (Plate 1). The gneisses commonly display tight to isoclinal asymmetric minor folds with amplitudes up to 4 m. In places the metamorphic layering is interrupted by cross-cutting stringers, dykes or irregular patches of granitic material, continuous with, or later than the parallel leucosome layers. Lenses, layers and boudins of dark grey to black, fine to medium-grained plagioclase amphibolite constitute less than 10 per cent of the gneisses, but occurs throughout this unit. The gneisses weather pale buff or grey.

Porphyroblastic gneisses have developed wherever the migmatites have undergone potash metasomatism. They are interspersed with lit-par-lit gneisses throughout the area, but are particularly well developed on the southeast shore of Ospwagan Lake and west shore of Middle Lake. The megacrysts, consisting of potassium feldspar, may attain lengths of 4 cm and account for up to 20 per cent of the rock. Feldspathization is most prominent in the vicinity of the cataclastic fault zones. All stages of growth and destruction of the porphyroblasts can be observed in moderately deformed cataclastic gneisses, indicating the contemporaneity of the two processes.

Microscopic examination reveals that the gneisses typically consist of interlocking anhedral sodic plagioclase and quartz, forming a granoblastic texture. Varying proportions of microcline are present in the potash-rich varieties. Reddish brown, and rarely brownish green, subhedral biotite exhibits a weak to strongly preferred orientation. Minor, randomly oriented green hornblende becomes increasingly prominent at the expense of biotite towards the southeast around Paint Lake. Plagioclase appears as clear to incipiently sericitized, equant grains which are commonly bent and fractured. Compositionally, the feldspar ranges from calcic oligoclase to sodic andesine and zoning is weak or absent. Quartz is clear and invariably strained. Comminution of the quartz is evident in rocks which have undergone cataclasis. Garnets rarely exceed 2 mm in diameter and are pale pink to neutral in body colour. They may be euhedral or rounded, and in strongly foliated portions of this unit, they are fragmented and crushed. Larger crystals display poikiloblastic texture.

Relict diopside and hypersthene were observed from localities between Provincial Road 391 and Paint Lake. Fibrous sillimanite was noted on the southeast shore of Middle Lake, and in sections from the highway where it crosses the eastern boundary of the map-area. One occurrence of cordierite, intergrown with poikiloblastic garnet, was found in an outcrop on Provincial Road 391, near the Paint Lake turn-off.

Accessory minerals include magnetite, apatite, zircon, rutile and locally, sphene. Chlorite, sericite, epidote and calcite occur throughout this unit as secondary alteration minerals in the vicinity of minor shears.

Porphyritic meta-picrite (A2a)

Unit A2 has been subdivided (A2a, 2b) on the basis of primary textural and structural features that are readily distinguishable in the field. The meta-picrites make up approximately one-half of the meta-volcanic rocks in the Ospwagan Lake area. The porphyritic variety (A2a) is well exposed on the north and south shores of the strip of land separating Upper and Lower Ospwagan Lakes, on portions of the east and west shore of Upper Ospwagan Lake, and as reef and shoreline exposures around a bay at the mouth of the Taylor River on Lower Ospwagan Lake.

Phenocrysts are the only well preserved primary feature within this rock type, although individual flows, approximately 10 m thick, can be distinguished in the vicinity of a small inlet on the southeast shore of Ospwagan Lake. The margins of the flows are devoid of phenocrysts over a width of 4 to 10 cm. At this locality the flows are gently folded into a shallow northeast-plunging syncline.

Fresh surfaces of the meta-picrite exhibit a dark grey aphanitic to fine-grained recrystallized groundmass, containing round, ovoid or lenticular, reddish brown, altered olivine phenocrysts. In places the groundmass can be distinguished in hand specimen as a felted mass of greenish black fibrous amphibole showing a preferred orientation. Weathered surfaces are olive green or light greenish grey in colour and have a distinctive pitted appearance, resulting from the weathering out of the phenocrysts (Plate 2).

The rock typically consists of a groundmass of tremolite and minor chlorite, which surround and partially replace the (deuterically) altered olivine phenocrysts. The tremolite forms ragged subhedral laths or needles, generally less than 1 mm in length. In one thin section, from the east shore of Upper Ospwagan Lake, slender randomly oriented needles up to 5 mm in length were observed. The fibrous amphibole is weakly pleochroic from colourless to pale green. Chlorite is absent in some sections, but others contain up to 20 per cent chlorite as felted masses. Chlorite is most common on the south and north shores of Lower and Upper Ospwagan Lakes respectively.

The altered olivine phenocrysts appear as corroded, anhedral crystals comprising 10 to 30 per cent of the rock. They display an ovoid or subrounded form in the least deformed outcrops, but are lenticular in cataclastic zones. The phenocrysts range from 2 to 10 mm in diameter, but in any single section their size is relatively uniform. The olivine is heavily fractured and altered to bright yellow, olive green, or reddish brown iddingsite. The amount of alteration ranges from incipient replacement around the rims, to complete serpentinization. Alteration of the olivine phenocrysts is considered to have been deuteric rather than metamorphic, as there is no relationship between the extent of the alteration and either the metamorphic grade or degree of cataclastic deformation to which the rocks have been subjected.

Accessory anhedral iron oxide, comprising about one per cent of the rock, is uniformly distributed throughout the groundmass and altered phenocrysts.

Meta-picrite flow breccia (A2b)

This non-porphyritic subunit is chemically similar to the porphyritic meta-picrite. It is characterized by homogeneous accumulations of what probably represent metamorphosed autoclastic volcanic fragments. In places, some small pillows are also present. The flow breccia appears to be conformably interlayered with the porphyritic flows, but the true thickness of individual layers is difficult to determine as the layers are commonly sheared and faulted (Plates 3 and 4).

The meta-picrite flow breccia makes up a minor portion of the total meta-picrite unit. It is best exposed along the shores of the strip of land dividing Upper and Lower Ospwagan Lakes. In an exposure about 300 m west of the small inlet on the south shore of Lower Ospwagan Lake, weathering has released complete breccia fragments of meta-picrite.

The rock is virtually monomineralic, consisting almost entirely of colourless to pale green tremolite, and only minor amounts of chlorite. The tremolite occurs as a homogeneous mass of slender, subhedral, interlocking needles arranged in a confused array or, in well foliated specimens, showing preferred orientation. The crystals range in length from less than 1 mm to 3 mm. Accessory iron oxide accounts for less than one per cent of the rock.

Eight whole rock chemical analyses of both porphyritic and nonporphyritic types of meta-picrite, together with their C.I.P.W. normative compositions, are presented in Table 2. Their chemical classification is treated in conjunction with the pillowed meta-basalt below.

Pillowed meta-basalt (A3)

The meta-basalt comprises a sequence of fine-grained amphibolites, in which deformed pillows are outlined by well preserved selvage zones. Pillow 'top' estimates in these rocks provide the only means of determining the stratigraphic sequence in the map-area. Primary structures indicating upward sequence have not been observed in the metasediments. The meta-basalt conformably overlies the meta-picrite (A2).

Table 2. Chemical analyses and C.I.P.W. molecular norms of meta-picrites

Sample No.	18-72-208	18-72-215	18-72-216*	18-72-217*	18-72-218	18-72-220	18-72-230*	18-72-413*	18-72-437*
SiO_2	46.8	43.6	48.0	46.65	47.7	45.65	42.9	46.45	47.05
Al_2O_3	11.0	7.9	6.8	6.8	8.15	8.55	7.15	9.0	4.90
Fe_2O_3	1.82	3.08	2.51	2.88	1.86	2.47	1.65	2.34	4.33
FeO	9.30	7.80	7.64	6.60	8.26	8.42	7.59	6.06	10.28
CaO	10.05	6.34	9.78	8.50	10.95	9.50	6.28	10.02	4.82
MgO	16.1	23.3	19.75	21.85	17.85	18.95	25.10	19.0	21.30
Na_2O	1.63	0.87	0.74	0.44	1.10	0.85	0.42	1.22	0.70
K_2O	0.09	0.11	0.05	0.03	0.06	0.22	0.03	0.12	0.44
TiO_2	0.75	0.50	0.55	0.41	0.37	0.56	0.38	0.62	1.40
P_2O_5	0.05	0.09	0.06	0.04	0.09	0.05	0.09	0.04	0.05
MnO	0.18	0.17	0.20	0.10	0.18	0.17	0.15	0.12	0.23
NiO	0.07	0.11	0.07	0.15	0.10	0.11	0.20	0.11	0.18
Cr_2O_3	0.25	0.32	0.17	0.54	0.37	0.40	0.49	0.44	0.08
H_2O	2.04	5.66	3.69	4.68	3.03	3.68	6.78	4.26	3.99
S	0.01	0.06	0.01	0.12	0.07	0.00	0.03	0.01	0.16
CO_2	0.10	0.75	0.20	0.15	0.15	0.20	0.95	0.15	-
TOTAL	100.2	100.6	100.2	99.9	100.5	99.8	100.2	99.9	99.9
Magnesium/iron ratio expressed as:									
$\frac{MgO \times 100}{MgO + (FeO + 0.8998\ Fe_2O_3)}$	59.54	68.79	66.61	70.39	64.25	64.04	73.46	69.93	60.03
OR	0.53	0.66	0.30	0.18	0.36	1.33	0.18	0.72	2.67
AB	14.63	7.95	6.73	4.02	9.94	7.95	3.88	11.10	6.44
AN	22.44	17.63	15.29	16.78	17.23	19.12	18.04	18.99	9.16
Cpx	21.68	11.01	26.80	20.69	29.47	22.84	10.72	24.91	12.02
Opx	12.02	24.24	33.82	39.37	21.20	21.26	27.39	18.48	52.41
OL	25.25	33.69	13.24	14.10	18.12	23.37	36.46	21.67	10.01
MT	1.90	3.28	2.66	3.06	1.96	2.63	1.77	2.48	4.64
IL	1.05	0.71	0.78	0.58	0.80	0.79	0.54	0.88	2.00
CR	0.28	0.36	0.18	0.61	0.42	0.46	0.56	0.90	0.09
AP	0.11	0.19	0.13	0.09	0.19	0.11	0.19	0.09	0.11
PY	0.03	0.16	0.03	0.32	0.18		0.08	0.03	0.43
TOTAL	99.92	99.88	99.96	99.80	99.87	99.86	99.81	99.85	99.98

* Contains modal olivine phenocrysts and/or iddingsite pseudomorphs.

Pillows, which show the least amount of deformation in the area, are well exposed on a small island and the nearby southern shore of Lower Ospwagan Lake. Pillows are also present on the broad peninsula and reefs on the east side of Lower Ospwagan Lake. The broad, high ridges bordering the west shore of Upper Ospwagan Lake, are composed predominantly of pillowed meta-basalt. This unit can be traced as far as the south end of the lake and thence intermittently around a large S-fold at the southern boundary of the map-area. On the west limb of this fold, the pillows have been deformed by minor S-folds which are related to the major structure. Pillows, exposed in the outcrops south of Upper Ospwagan Lake, are characterized on weathered surfaces by pale greenish grey calc-silicate-rich cores enclosed by greenish black rims. Pillows of this type are exposed on both sides of Provincial Road 391 and in a creek draining into the south end of Upper Ospwagan Lake. Meta-basalt on the east shore of Upper Ospwagan Lake contains highly deformed and almost unrecognizable pillows.

The meta-basalt consists of fine-grained, greenish black foliated hornblende-plagioclase amphibolite. On greenish grey weathered surfaces, the pillow boundaries are accentuated by the development of narrow, black, monomineralic amphibolite rims, which are separated from adjoining pillows by a white, plagioclase-rich selvage zone.

The present shape of the pillows is a result of compression and, in some locations, shearing, associated with the development of the main zones of cataclasis. The least deformed pillows have an elliptical outline on flat surfaces, but are commonly elongate, such that the longest axes of the pillows plunges to the northeast. The pillows have been asymmetrically compressed with respect to the original layering, so that pillow 'tops', based on the position of protuberances between adjacent, underlying pillows, give only approximate, but nevertheless significant, stratigraphic tops. Such pillows are exposed on the small island near the south shore of Ospwagan Lake (Plate 5). Their outcrop length-width ratio is about 3:1. The most highly deformed pillows on the east shore of Upper Ospwagan Lake show a combination of both compression and attenuation through cataclasis, producing length:width ratios in excess of 20:1. All gradations between these extremes occur in the remaining areas where pillows are exposed.

There is a general increase in the size of individual pillows from southwest to northeast in the map-area. The largest pillows (up to 4 m in length) were observed on the east shore of a bay due south of Niven Point.

The meta-basalt typically consists of metamorphic hornblende and plagioclase. The hornblende is idiomorphic to hypidiomorphic and comprises between 60 and 80 per cent of the rock. It is strongly pleochroic from pale to deep green or bluish green, and displays a weak to well defined preferred orientation. The prismatic crystals are generally between 0.5 and 1 mm in length and have a length:width ratio of between 2 and 4:1. The black spotted appearance of some outcrops on the west shore of Upper Ospwagan Lake is attributed to the development of coarse amphibole crystal aggregates in a finer grained matrix. This may be a contact metamorphic effect, developed in association with the intrusion of large granite pegmatites in the vicinity. Plagioclase forms xenomorphic grains which are 'interstitial' to the hornblende, and generally range in size from 0.1 to 0.5 mm. The composition varies between An_{36} and An_{60}, although within individual thin sections the range is less than 15 per cent. The feldspar exhibits inverse (metamorphic) zoning with a core that may be 10 per cent more sodic than the rim. Grains are clear and larger crystals commonly display a combination of albite and pericline twinning.

Chemistry

Whole rock chemical analyses of 12 samples of meta-basalt are presented in Table 3, together with their magnesium/iron ratios and C.I.P.W. molecular normative compositions. The locations of chemically analyzed samples of mafic and ultramafic rocks in the study area are shown in Figure 3.

All but one of the meta-basalts plot within the 'Basalts' field as defined by Baragar and Goodwin (1969) based on normative plagioclase composition versus normative colour index (Figure 4). Using the chemical classification adopted by Irvine and Baragar (1971) in which total alkalis are plotted against silica content (Figure 5) the meta-basalts and meta-picrites fall dominantly within the subalkaline field. The meta-basalts exhibit a dominantly tholeiitic trend on a plot of normative plagioclase composition versus alumina content (Figure 6). Similarly, the meta-basalts and meta-picrites mostly lie within the tholeiitic field of an AFM ternary plot, and although separated by a gap, lie on the same differentiation trend (Figure 7). This suggests derivation from a single parent magma. No intermediate or acid varieties of volcanic rocks have been recognized in the map-area, nor to the writer's knowledge, anywhere along the Manitoba nickel belt.

Table 3. Chemical analyses and C.I.P.W. molecular norms of meta-basalts

Sample No.	18-72-210-2	18-72-212-2	18-72-214-1	18-72-222	18-72-223	18-72-289	18-72-290	18-72-387	18-72-403	18-72-430	18-72-587-1*	18-72-587-2†
SiO_2	50.3	53.55	51.75	50.55	51.05	46.7	56.75	49.7	50.13	49.03	51.75	50.45
Al_2O_3	12.35	14.1	13.9	12.7	17.8	17.25	14.65	12.5	13.05	13.1	13.85	14.95
Fe_2O_3	1.94	1.39	1.53	0.89	0.86	1.41	1.28	1.66	1.20	1.55	1.01	1.55
FeO	14.40	8.18	8.88	8.88	8.18	9.42	6.85	9.13	9.09	8.96	6.77	8.63
CaO	8.93	9.57	11.86	12.99	9.12	6.70	5.69	11.32	11.98	11.06	17.66	12.44
MgO	6.33	8.44	8.53	9.18	6.63	8.80	6.48	10.60	9.22	11.02	6.54	0.25
Na_2O	1.86	2.47	1.74	1.55	3.35	2.96	4.65	1.98	2.15	1.78	0.70	1.42
K_2O	0.09	0.30	0.09	0.09	0.32	1.25	0.68	0.17	0.17	0.17	0.11	0.16
TiO_2	1.86	0.78	0.81	0.79	0.65	0.92	0.83	0.79	0.87	0.86	0.85	1.00
P_2O_5	0.19	0.04	0.08	0.04	0.13	0.12	0.05	0.08	0.08	0.10	0.11	0.12
MnO	0.27	0.17	0.17	0.18	0.19	0.17	0.10	0.18	0.16	0.18	0.16	0.16
H_2O	1.28	1.20	0.96	1.39	0.91	3.30	1.77	1.19	1.10	1.44	0.57	1.03
CO_2	0.15	0.15	0.15	0.25	0.15	0.65	0.20	0.10	0.05	0.15	0.05	0.05
TOTAL	99.9	100.3	100.4	99.5	100.0	99.5	100.0	99.4	99.2	99.4	100.3	100.2
Magnesium/iron ratio expressed as:												
$\frac{MgO \times 100}{MgO + (FeO + 0.8998\ Fe_2O_3)}$	28.16	47.23	45.40	48.67	42.55	45.15	44.75	49.95	47.55	51.57	45.35	45.16
Q	4.71	3.43	2.95	1.02			2.82				6.04	2.62
OR	0.56	1.79	0.54	0.55	1.91	7.64	4.06	1.02	1.03	1.02	0.67	0.96
AB	17.53	22.41	15.85	14.29	30.40	27.48	42.09	18.09	19.69	16.28	6.42	12.98
AN	26.33	26.79	30.29	28.18	32.94	30.84	17.24	25.16	25.97	27.77	35.07	34.58
Cpx	15.09	16.75	22.57	30.21	9.55	2.19	8.72	25.17	27.30	21.97	42.96	21.99
Opx	30.51	26.17	24.34	23.58	16.49	3.84	22.46	21.32	18.80	23.10	6.32	23.55
OL					6.62	24.90		6.18	4.54	6.76		
MT	2.11	1.47	1.62	0.96	0.91	1.52	1.35	1.77	1.28	1.65	1.08	1.65
IL	2.72	1.10	1.45	1.13	0.92	1.33	1.67	1.12	1.24	1.22	1.21	1.42
AP	0.42	0.09	0.17	0.09	0.28	0.26	0.11	0.17	0.17	0.21	0.24	0.26
TOTAL	99.98	100.00	99.78	100.01	100.02	100.00	100.52	100.00	100.02	99.98	100.01	100.01

* Pillow core

† Pillow rim

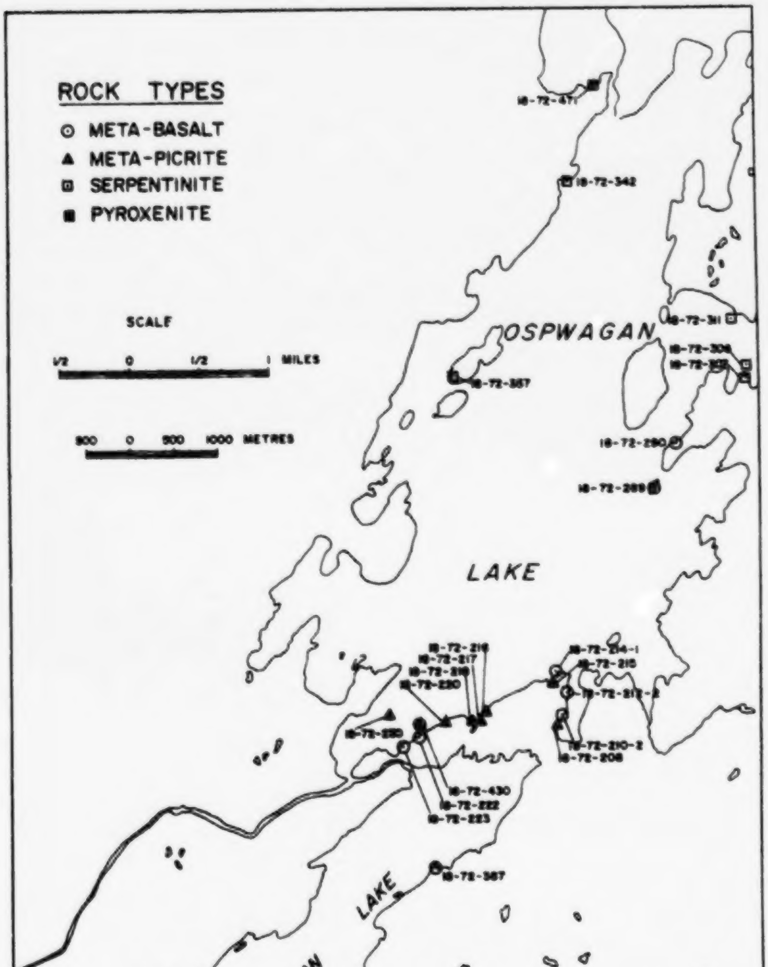

ROCK TYPES
⊙ META-BASALT
▲ META-PICRITE
⊡ SERPENTINITE
■ PYROXENITE
SCALE
1/2 0 1/2 1 MILES
500 0 500 1000 METRES
OSPWAGAN
LAKE
UPPER OSPWAGAN LAKE
MIDDLE LAKE
MID LAKE
18-72-471
18-72-342
18-72-311
18-72-306
18-72-357
18-72-290
18-72-289
18-72-216
18-72-217
18-72-218
18-72-220
18-72-230
18-72-214-1
18-72-215
18-72-212-2
18-72-210-2
18-72-208
18-72-430
18-72-222
18-72-223
18-72-367
18-72-413
18-72-403
18-72-387-1

FIGURE 3. Location of chemically analyzed samples listed in Tables 2, 3 and 4.

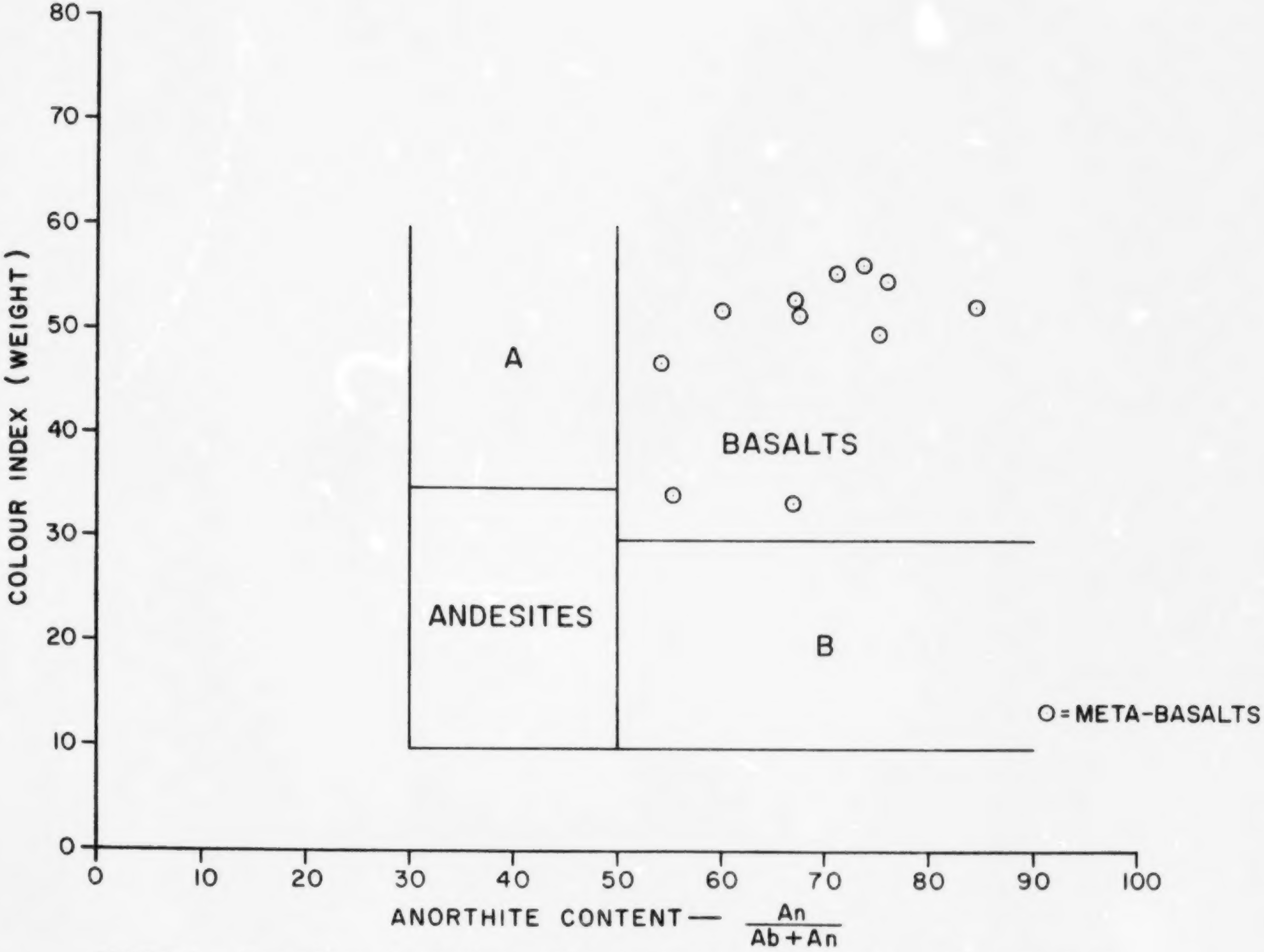


FIGURE 4. Normative plagioclase composition vs. colour index for samples of meta-basalts in the Ospwagan Lake area. Basalt-andesite classification after Baragar and Goodwin (1969).

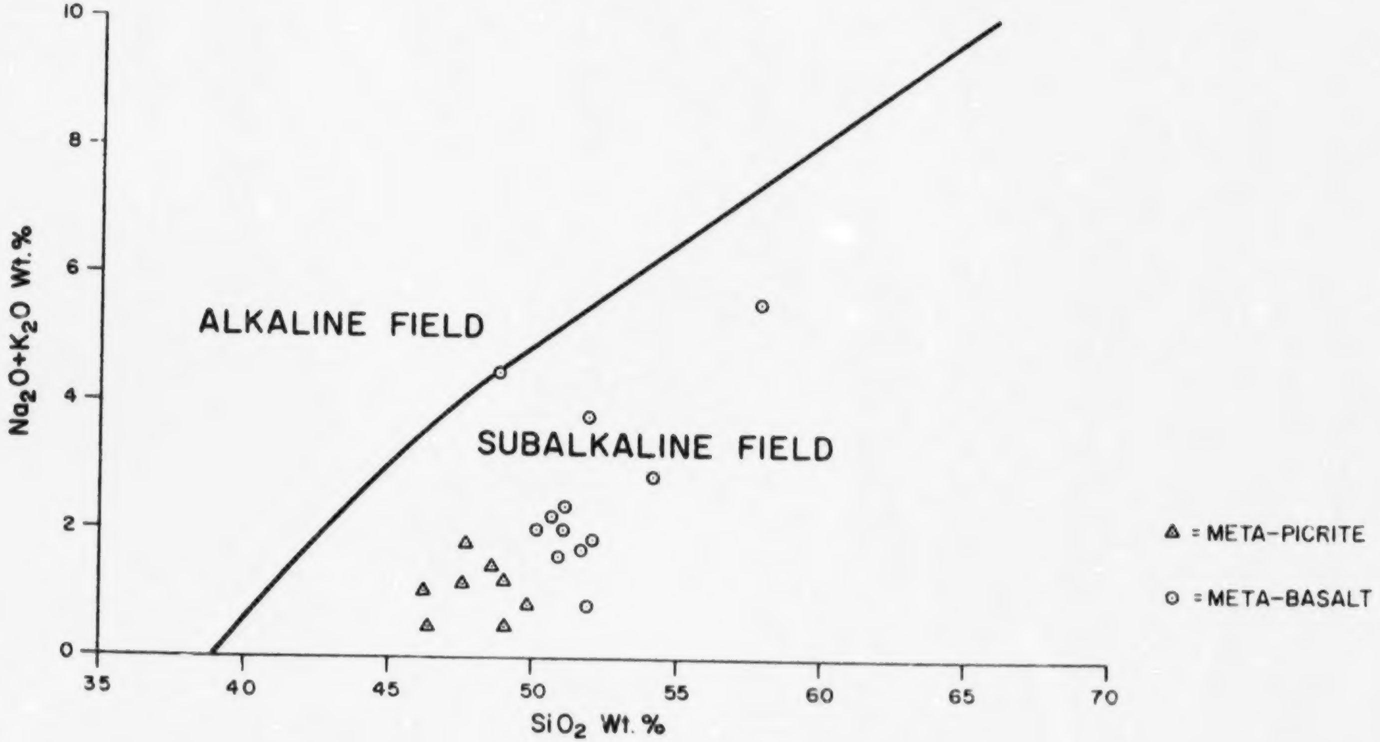


FIGURE 5. Total alkali vs. silica for samples of meta-basalt and meta-picrite in the Ospwagan Lake area. Alkaline-subalkaline divisions after Irvine and Baragar (1971).

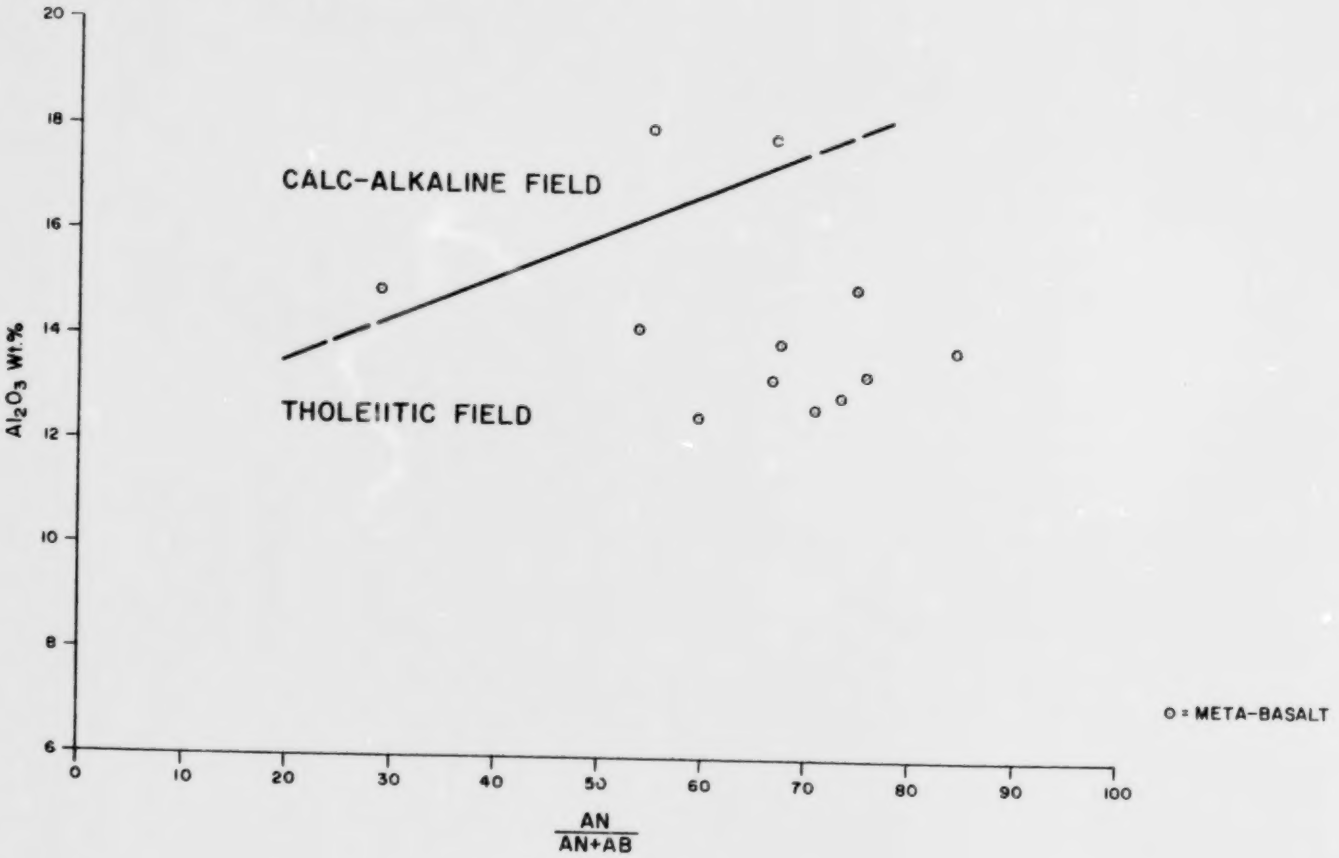


FIGURE 6. Normative plagioclase compositions vs. alumina for samples of meta-basalts in the Ospwagan Lake area. Calc-alkaline-tholeiitic division after Irvine and Baragar (1971).

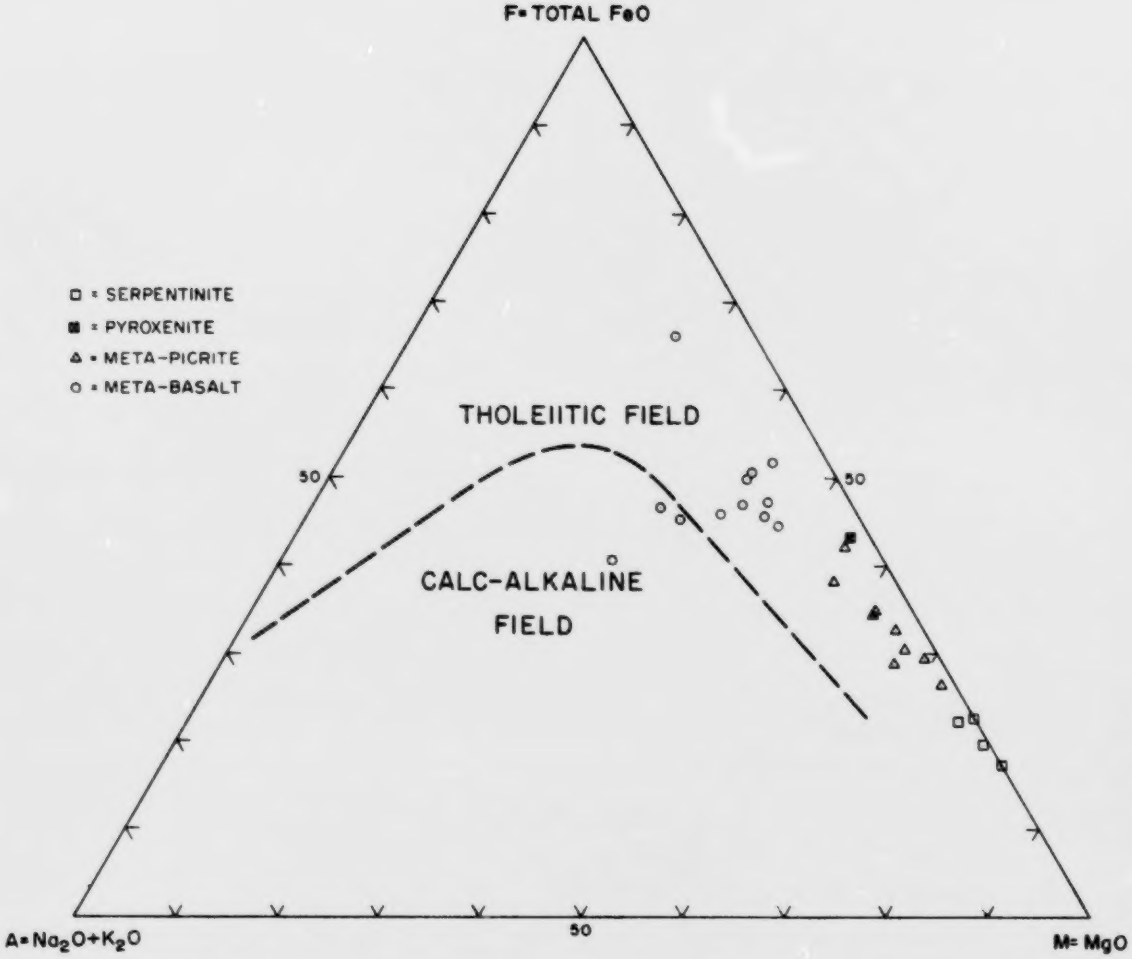


FIGURE 7. AFM plot for Ospwagan Lake meta-basalt, meta-picrite and ultramafic rocks. $A = Na_2O + K_2O$; $F = FeO + 0.8998\ Fe_2O_3$; $M = MgO$, all in weight per cent. Calc-alkaline-tholeiitic division after Irvine and Baragar (1971).

Meta-greywacke (A4a) and mafic laminated tuff (A4b)

A northeast to north-trending, steeply dipping formation of micaceous, clastic, quartzo-feldspathic rock outcrops on the south and northeast shores of Ospwagan Lake, and continues northeast beyond the east boundary of the map-area. The rocks are either massive or thinly laminated and overlie the meta-basalts. The latter pinch out northeastwards against the metasediments.

The unit has been subdivided into a massive, medium to coarse grained feldspathic meta-greywacke (A4a) and a thinly laminated, fine grained mafic tuff (A4b). The meta-greywacke outcrops on the north and south shores of the peninsula due east of the large island on Ospwagan Lake. It is a dark grey, non-bedded and weakly foliated rock, consisting mostly of plagioclase and quartz with rare lithic fragments. Stretched, lenticular clasts, composed predominantly of chert, range in size from 0.1 to 5 cm in length and comprise less than 5 per cent of the rock. Traces of finely disseminated pyrrhotite and chalcopyrite occur locally.

Under the microscope, the feldspathic meta-greywacke is seen to consist of saussuritized sodic plagioclase, surrounded by fine-grained granular quartz, sericite, chlorite and biotite. The plagioclase, which comprises 50 to 70 per cent of the rock, occurs as poorly sorted, rounded and corroded grains, which are commonly bent and fractured. In places the micaceous constituents impart a weak foliation to the rock.

The mafic laminated tuff (A4b) is a fine-grained, silty rock, containing a variable but high proportion of mafic constituents. It is identified by thin, parallel, and continuous laminae whose individual thickness range from less than 0.1 to 3 cm. Chert or quartz and feldsparrich laminae alternate with streaks or bands of biotite and/or hornblende-rich material. The multi-coloured bands range through black, grey, buff and white. Weathered exposures are various shades of greenish grey and white (Plate 6). The laminated tuff is best exposed along the west shore of Niven Point. Finely laminated rocks also occur on the northeast shore of Ospwagan Lake.

The tuff consists of a fine-grained, poorly sorted, recrystallized, quartzo-feldspathic groundmass, containing up to 50 per cent biotite and varying minor proportions of chlorite, muscovite and calcite. The biotite has a preferred orientation, and its variable concentration across strike accounts for the colour differences of individual laminae which may be a reflection of the original bedding. The biotite is locally replaced by pale green hornblende in outcrops at the north end of Ospwagan Lake.

On Niven Point, garnet porphyroblasts, 1 to 2 mm in diameter, show evidence of syn- and late-tectonic growth in cataclastically deformed zones. These zones are several metres in width and are parallel to the laminations. Rare, tourmaline-rich bands commonly occur between chert and mica-rich horizons. The tourmaline occurs as randomly oriented minute needles which lie within the foliation planes.

Meta-arkose and feldspathic quartzite (A5)

This steeply dipping, northeast to north-trending unit conformably overlies the meta-greywacke and laminated tuff (A4) in the northeastern portion of Ospwagan Lake, but underlies the metavolcanic rocks (A2a) on Upper Ospwagan Lake. It is distinguished from the metasediments of Unit A4 by its much lower content of argillaceous detrital material, and is consequently a cleaner and more massive quartzo-feldspathic sediment. Quartz and plagioclase comprise 85 per cent or more of the rock. Plagioclase occurs in amounts of between one and two-thirds of the total rock. Interlayered with this sequence are rocks containing less than one-third feldspar. These are classified as feldspathic quartzites although they have not been distinguished as such on the accompanying map.

The metasediments are well exposed around the large island in Ospwagan Lake, on the peninsula to the north of the island, and on the intervening reefs. They outcrop again on the north shore of the lake and continue northeast beyond the map-area (Plate 7). In this region they attain their greatest exposed thickness of about 850 m. The unit is a fine to medium-grained, dark bluish grey to black rock, and massive or finely laminated. The rock is brittle and breaks with a characteristic conchoidal fracture. Exposed surfaces weather a light bluish grey or buff. Similar rocks of more massive appearance are exposed on the east and west shores of Upper Ospwagan Lake. Here, pillow 'tops' on the west side of the lake, indicate that the metasediments underlie the volcanic flows.

Indications of a clastic origin are better preserved in this unit than in the more argillaceous meta-greywacke and tuff, owing to the inherent resistance to metamorphic alteration of the quartzo-feldspathic rocks. Quartz and feldspar occur as angular to subangular, poorly to moderately sorted grains, and normally range in size from 0.5 to 2 mm. Serrated grain boundaries are commonly observed in optically strained quartz. The feldspar is generally fresh and consists predominantly of sodic plagioclase with variable, but minor proportions of microcline. Zoisite and traces of calcite occur interstitially in some thin sections. Magnetite, zircon and rutile are common accessories.

Where deformed by cataclasis, the meta-arkoses and feldspathic quartzites have recrystallized to a polygonal mosaic of clear interlocking quartz and feldspar grains, with the interspersed micas showing a preferred orientation. Primary layering cannot be distinguished from cataclastically imposed lamination, and therefore bedding symbols have not been used for the metasediments on the geological map.

Amphibolite (A6a)

The term amphibolite has been used to describe a series of rocks consisting mainly of amphibole and plagioclase in which the former constituent is dominant. These rocks are widespread although they form only a small part of subarea A.

The amphibolites occur as conformable tabular bodies, or as lenses, blocks and boudins in a variety of host rocks, and are undoubtedly of more than one age. Only the larger bodies are shown on the accompanying geological map.

The largest amphibolite body strikes northeast along the Taylor River and is intermittently exposed over a total length of 5 miles (8 km). The amphibolite appears to be conformable with the layering in the adjoining gneisses although its contacts are not exposed. Its estimated width is between 100 and 300 m. Similar bands of amphibolites, with the same strike, outcrop at several locations to the northeast, along the northwest shore of Ospwagan Lake. Smaller bands, blocks and lenses of amphibolite, 0.1 to 3 m in width, occur elsewhere in the area, within the metasediments, gneisses and cataclastic rocks. The amphibolite bodies have sharp contacts which are generally parallel to the foliation or metamorphic layering in the adjoining rocks. Tightly folded, asymmetrically folded or boudinaged bodies occur locally. On a reef west of Niven Point, the amphibolite boudins in mylonite have been rotated such that they transgress the cataclastic foliation in the enclosing blastomylonite (Plate 8).

The amphibolites exhibit a uniformly medium-grained texture and consist essentially of hornblende and plagioclase. Hornblende, which normally comprises 60 to 90 per cent of the rock, is typically idiomorphic and strongly pleochroic, with a blue-green or deep green body colour. The amphibole prisms have a preferred planar orientation which defines the foliation. Finely granulated material is present along crystal boundaries in samples that exhibit cataclasis. Plagioclase forms xenomorphic grains which are normally free of inclusions and display combination albite-pericline twinning. In composition it varies from calcic andesine to sodic labradorite and may show reverse zoning, resulting in a soda-rich core, similar to the plagioclase in the meta-basalts.

Several thin sections of amphibolites from widely spaced localities contain minor amounts of relict clinopyroxene, which is highly deformed, smeared out and partially replaced by hornblende. Reddish brown biotite occurs locally. Sphene is a common accessory in the larger amphibolite bodies and generally forms aggregates of euhedral diamond-shaped crystals. Other accessories include magnetite, pyrite and pyrrhotite. A thin section from the central portion of the large amphibolite body along the Taylor River contains second generation, randomly oriented, poikiloblastic hornblende xenoblasts which have partially replaced earlier plagioclase and hornblende.

The generally uniform texture, lack of recognizable primary sedimentary features, presence of a titanium-bearing accessory (sphene) and mineralogical similarity to metamorphosed volcanic rocks in the area suggest an igneous and possibly extrusive origin for the amphibolites.

Orthopyroxene-garnet gneiss (A6b)

An unusual dark greenish grey metamorphic rock, of mottled appearance and mafic composition, is exposed on the south shore of Mid Lake on the southern boundary of the map-area. Its contacts with the enclosing gneisses (A1) are not exposed in the map-area. It consists of 30 to 50 per cent pink poikiloblastic garnets, intergrown with coarse, pleochroic, pale bluish green orthopyroxene, and fine granular quartz. Brown biotite is a minor component and accessory magnetite occurs locally. In places, the pyroxene has undergone partial replacement by green hornblende. From 2V measurements, the pyroxene has been found to be bronzite, with an En content of 80 and 82 per cent.

The origin of this rock is in doubt, but it is possible that it originated as a mafic intrusion, which was subsequently thermally metamorphosed.

Serpentinite and serpentinized peridotite (A7a)

Most of the ultramafic bodies in the Ospwagan Lake area are covered by water or underlie swamps, and their outlines on the accompanying map have been reproduced from the regional map of the nickel belt (Quirke et al., 1970; Coats et al., 1972, map-unit 11). Because of their relative susceptibility to weathering, they are rarely exposed, and only a few small shoreline outcrops and boulder reefs are visible in the map-area. The importance of locating and defining these bodies arises from their well established association with massive nickel sulphide deposits.

Serpentinite and serpentinized peridotite are the most common ultramafic rock types in the area although a single clinopyroxenite exposure (A7b) has also been recognized. The largest ultramafic body, underlying Ospwagan Lake, has been defined by geophysical surveys and diamond drilling. Geological details of this and other bodies outlined in the area remains confidential to The International Nickel Company of Canada, Limited. Disseminated sulphide mineralization is commonly found associated with these bodies in adjoining metasedimentary rocks. As outlined from the regional map, the ultramafic intrusions form long continuous, steeply dipping, northeast-trending conformable bodies in metasedimentary and gneissic host rocks. The best exposure of serpentinite is located on the northern point of a broad peninsula on the east side of Ospwagan Lake. At low water level serpentinite reefs are exposed at the entrance to the adjoining bay.

The rock is medium grained, bluish or greenish black, and contains small patches or streaks of red serpentine. Weathered surfaces are pale bluish grey and have a rough 'crocodile skin' texture in which the outline of original rounded olivine grains are clearly visible. This body is remarkably undeformed but it is bounded on the west by vertical faults with vertically plunging slickensides.

The serpentinite has a well preserved cumulate texture in which the original olivine has been replaced by inward-directed fibro-lamellar crystals of serpentinite. Relics of olivine, cut by serpentine-filled fractures, are preserved in the cores of some of the pseudomorphs, although generally the serpentinization is complete. Fine felted masses of serpentine also occur interstitially, forming pseudomorphs after poikilitic pyroxene. Magnetite-filled cleavage traces define the size and shape of the original pyroxene crystals. The cumulate minerals account for between 60 and 80 per cent of the rock. Magnetite makes up about 10 per cent of the rock. Colourless clinochlore occurs as a minor constituent in aggregates of bent crystal laths, commonly interleaved with magnetite. An unidentified, optically continuous, strongly pleochroic reddish brown mineral, filled with dusty inclusions appears here and there as poikiloblastic crystals which enclose the pseudomorphs after olivine. The latter have well rounded grain boundaries suggestive of flow abrasion prior to consolidation of a crystal mush. The crystals now appear "suspended" in the intercumulate phase, or are packed together so that the matrix volume is reduced to a minimum. Late stage alteration has introduced carbonate minerals along microfractures, and locally this material has replaced former matrix minerals.

On the west side of Ospwagan Lake, a small exposure of serpentinite, containing magnetite stringers, outcrops near the southwest tip of the largest of three islands. Reefs and boulders of serpentinite also occur in a small bay on the northwest shore of the lake. The original texture of the magnetite-bearing serpentinite has been destroyed. The fine serpentine matte is seen in thin section to have been partially replaced by aggregates of 2 to 3 mm long, randomly oriented blades of tremolite. The amphibole occupies 20 to 30 per cent of the rock and is accompanied by minor clinochlore and magnetite.

Chemistry

Chemical analyses, magnesium:iron ratios, and C.I.P.W. molecular normative compositions of five serpentinite samples and a single analysis of clinopyroxenite (A7b) are given in Table 4. The location of the analyzed samples is shown in Figure 3. The analyses have been plotted on the AFM diagram shown in Figure 7 where they form a continuous differentiation series with the extrusive rocks towards iron enrichment. The relative abundances of chromium and nickel oxides in the serpentinites range from 1:1 to 3:1. Low Cr_2O_3:NiO ratios are characteristic of Alpine-type peridotites whereas higher ratios characterize layered shield-type peridotites (Irvine and Findlay, 1972) as shown in Figure 8. The meta-picrites and clinopyroxenite have Cr_2O_3:NiO ratios which vary between 2:1 and 4:1, and plot within the layered shield-type peridotite field.

Clinopyroxenite (A7b)

Only one exposure of clinopyroxenite has been found in the Ospwagan Lake area. It is located just west of the narrow entrance to the Manasan River at the north end of Ospwagan Lake.

The exposed pyroxenite is a dense, medium to coarse-grained, greenish black rock, located in cataclastic augen gneiss. The extent and attitude of the body cannot be determined from the limited exposure. The rock comprises short, tabular, anhedral crystals of colourless augite. The augite crystals measure 2 to 3 mm in length and display an irregular interlocking fabric. Minor green hornblende and brown biotite occur interstitially, together with traces of iron oxide.

Table 4. Chemical analyses and C.I.P.W. molecular norms of ultramafic rocks

	Serpentinized peridotite					Pyroxenite
Sample No.	18-72-306	18-72-307	18-72-311	18-72-342	18-72-357	18-72-471
SiO_2	37.05	38.65	39.85	43.60	39.80	44.45
Al_2O_3	2.60	2.65	2.20	6.90	2.65	3.50
Fe_2O_3	4.87	6.65	5.84	4.91	5.28	5.85
FeO	5.25	3.45	2.23	4.62	3.68	10.87
CaO	2.15	0.30	0.38	4.25	1.18	20.20
MgO	33.40	35.10	36.60	27.55	34.70	11.70
Na_2O	0.00	0.00	0.00	0.50	0.22	0.40
K_2O	0.00	0.00	0.00	0.20	0.15	0.28
TiO_2	0.11	0.12	0.11	0.11	0.13	0.95
P_2O_5	0.02	0.04	0.02	0.01	0.02	0.10
MnO	0.15	0.12	0.07	0.13	0.07	0.22
NiO	0.28	0.27	0.33	0.16	0.24	0.16
Cr_2O_3	0.49	0.64	0.28	0.23	0.76	0.32
H_2O	10.55	11.35	11.60	7.55	10.90	0.77
S	0.04	0.06	0.14	0.08	0.02	0.21
CO_2	2.60	0.30	0.50	0.20	0.15	1.25
TOTAL	99.55	99.70	100.1	100.95	99.95	101.15
Magnesium/iron ratio expressed as:						
$\frac{MgO \times 100}{MgO + (FeO + 0.8998\ Fe_2O_3)}$	77.57	78.82	83.03	75.29	80.45	42.04
C	0.00	2.51	1.76	0.00	0.03	0.00
OR	0.00	0.00	0.00	1.21	0.92	0.00
AB	0.00	0.00	0.00	4.58	2.04	0.00
AN	7.57	1.28	1.81	16.30	5.91	7.19
Cpx	2.94	0.00	0.00	4.10	0.00	70.08
Opx	26.83	46.23	45.21	37.45	35.61	0.00
FO	53.55	41.27	44.34	29.80	47.78	5.62
FA	2.57	0.03	0.00	1.37	0.57	1.94
LA	0.00	0.00	0.00	0.00	0.00	2.56
MT	5.43	7.26	5.01	4.46	5.70	6.35
IL	0.16	0.18	0.16	0.16	0.19	1.37
CR	0.58	0.75	0.32	0.26	0.88	0.37
HM	0.00	0.00	0.86	0.00	0.00	0.00
AP	0.05	0.09	0.04	0.02	0.04	0.22
PY	0.11	0.16	0.38	0.21	0.05	0.57
LC						1.38
NE						2.24
TOTAL	99.79	99.76	99.89	99.92	99.72	99.29

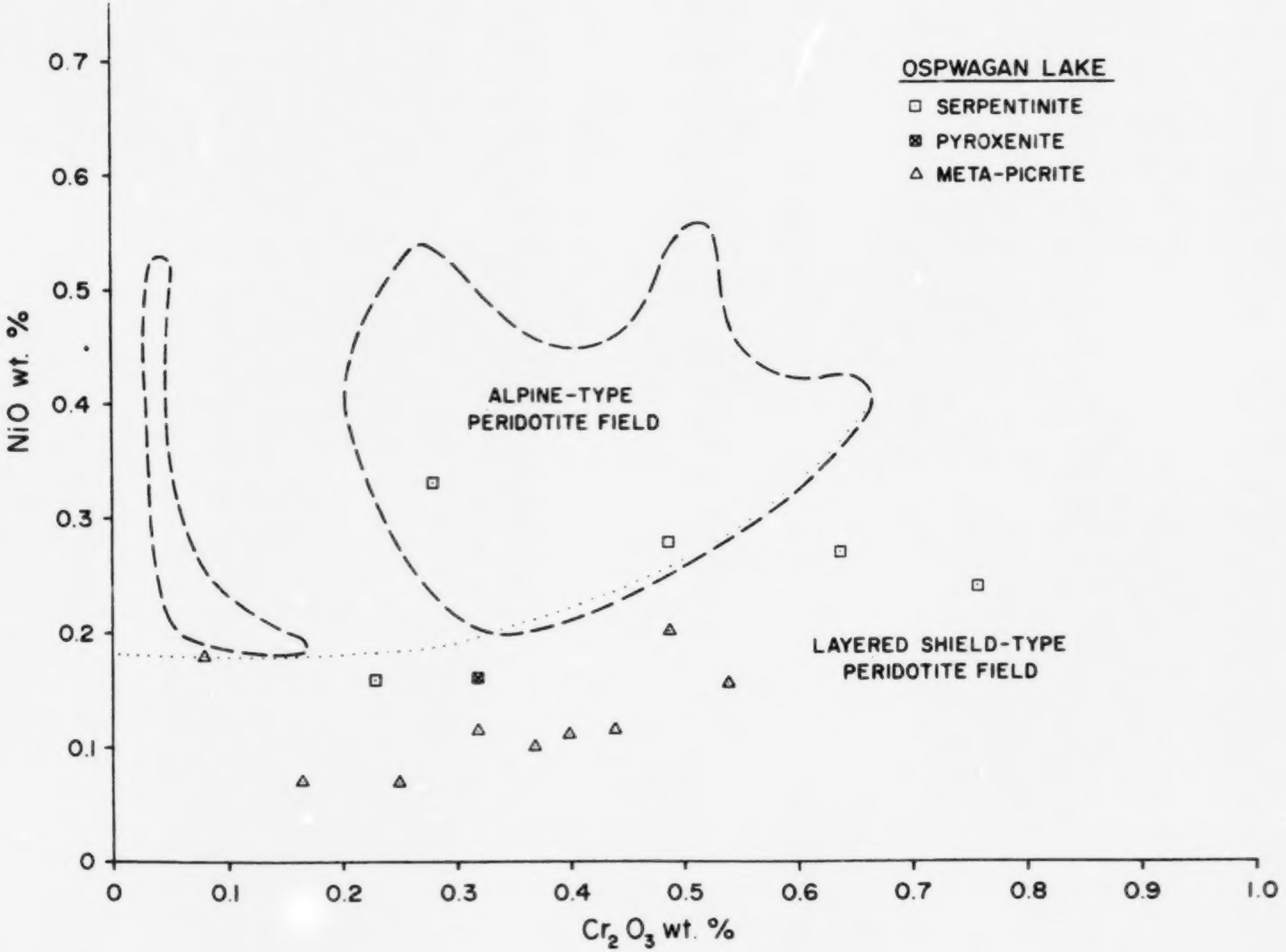


FIGURE 8. NiO-Cr_2O_3 plot in weight per cent for Ospwagan Lake meta-picrite and ultramafic rocks. Dashed line encloses analyses from Bay of Islands, Mount Albert, Blue River and Mayaguez complexes. Most of the analyses from the Muskox Intrusion lie below the dotted line. Data from Irvine and Findlay (1972).

A chemical analysis of this rock and its C.I.P.W. molecular norm is included with the serpentinite analyses in Table 4. The location of the analyzed sample is shown in Figure 3.

Granite pegmatite and aplite (A8)

Several ages of pegmatite intrusion, in a variety of host rocks, are exposed around the shores of Lower and Upper Ospwagan Lakes. The largest pegmatite body outcrops on the south shore of Lower Ospwagan Lake in prominent white cliffs [illegible] m high. The body trends northeast, is approximately 300 m wide, and is surrounded by meta-picrite. It is weakly foliated and together with several parallel, foliated satellite dykes on either side, must be pre- or early syn-kinematic in relation to cataclasis.

Three smaller dykes, ranging in width from 75 to 150 m, intrude the meta-basalts at intervals along the west shore of Upper Ospwagan Lake. The dykes are massive or weakly foliated and trend east, but their true shape and extent cannot be determined from the limited exposure. The most southerly of these bodies contains partially assimilated gneissoid xenoliths near the contacts. Potassium feldspar crystals up to 30 cm in length were noted towards the centre of this intrusion.

Perthitic microcline appears to be the dominant feldspar in all the pegmatite bodies. Oligoclase and quartz are the other major constituents. Muscovite is normally present, but comprises less than 5 per cent of the rock. Small amounts of biotite, epidote and chlorite may also be present, together with rounded pinhead-sized garnets in the more foliated varieties. All the large pegmatite intrusions lack any discernible mineralogical zoning.

Numerous small pegmatite and aplite dykes, not shown on the accompanying geological map, intrude all other rock types in the area including the mylonitic rocks. These minor intrusions are commonly zoned and range from several centimetres to a metre or more in width. They are considered to be a late- or post-kinematic phase of intrusion relative to the cataclastic deformation. They commonly outcrop along the west shore of Ospwagan Lake and strike predominantly northwest. They are also fairly abundant in the meta-basalts south of Upper Ospwagan Lake.

Quartzo-feldspathic mylonite gneiss (A9a), blastomylonite (9b) and mylonite (9c)

The Manitoba nickel belt is characterized in part by a set of major northeast-trending, steeply southeast-dipping bifurcating faults which manifest themselves as zones of cataclasis. Within the present map-area, two major cataclastic fault zones have been recognized, and are shown as unit A9 on the accompanying map. These zones are 200 to 500 m in width. The southwestern fault zone can be traced intermittently along the east shores of Upper and Lower Ospwagan Lakes and across the eastern map-boundary. The northwestern zone lies close to, or along the northwest boundary of subarea A (Wabowden Subprovince) and is well exposed around the west shore and adjoining islands on Ospwagan Lake. Several outcrops of cataclastic rocks, east of the Taylor River and on the north shore of Ospwagan Lake, are presumed to be on the southwest and northeast continuations of this zone respectively. A poorly exposed cataclastic zone in the northeastern part of the map-area follows the Manasan River and appears to mark the boundary between subareas A and B. Minor parallel zones of cataclasis are common within the adjoining rocks.

The division of cataclastic rocks in the Ospwagan Lake area into three subunits, is based on field and microscopic criteria, and follows the classification of cataclastic rocks developed by Higgins (1971). This is the most recent and useful grouping of these rocks, and is based on an extensive study of cataclastic zones by Higgins in the United States, Scotland and New Zealand (Table 5). Cataclastic rocks are initially grouped by Higgins according to whether or not they have primary cohesion. Rocks without primary cohesion are termed fault breccias and fault gouge. Rocks with primary cohesion are subdivided on the basis of whether cataclasis was dominant over neomineralization and recrystallization. Where cataclasis was the dominant process, the rocks are further subdivided into those that have 'fluxion structure' and those which do not. The former are termed microbreccia or cataclasite, and the latter, protomylonite, mylonite and ultramylonite. Those rocks in which neomineralization and recrystallization were the dominant processes and which contain 'fluxion structure' are termed mylonite gneiss and blastomylonite. The final subdivision is based on the approximate volume and size of porphyroclasts or fragments in the cataclastic rocks.

The term 'fluxion structure', first used by Lapworth (1885) in the original definition of 'mylonite', is defined by Higgins (1971) as:

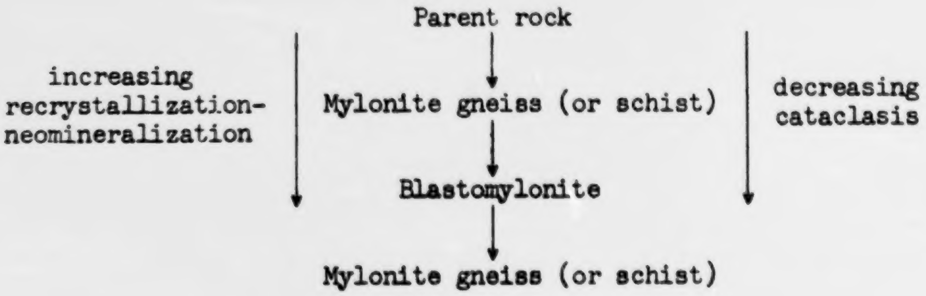
<table>
<tr><td rowspan="3">Approximate volume percent porphyclasts in rocks *with* fluxion structure
or
Approximate volume percent fragments in rocks *without* fluxion structure</td><td>Rocks *without* primary cohesion</td><td colspan="4">Rocks *with* primary cohesion</td><td rowspan="3">Approximate size of *most* porphyroclasts in rocks *with* fluxion structure
or
Approximate size of *most* fragments in rocks *without* fluxion structure</td></tr>
<tr><td rowspan="2"></td><td colspan="3">Cataclasis dominant over neomineralization-recrystallization.</td><td>Neomineralization – recrystallization dominant over cataclasis.</td></tr>
<tr><td>Rocks *without* fluxion structure</td><td colspan="2">Rocks *with* fluxion structure</td><td>Rocks *with* fluxion structure</td></tr>
<tr><td>>50</td><td rowspan="2">Fault breccia</td><td rowspan="2">Microbreccia</td><td colspan="2">Protomylonite</td><td rowspan="2">Mylonite gneiss (mylonite schist)</td><td rowspan="2">Visible to naked eye</td></tr>
<tr><td><50</td><td rowspan="2">Mylonite</td><td rowspan="3">Phyllonite (variety)</td></tr>
<tr><td>30
>10</td><td rowspan="2">Fault gouge</td><td rowspan="2">Cataclasite</td><td rowspan="2">Blastomylonite</td><td>>0.2 mm</td></tr>
<tr><td><10</td><td>Ultramylonite</td><td><0.2 mm</td></tr>
</table>

All rocks are gradational

Table 5. Classification of cataclastic rocks (after Higgins, 1971).

> "Cataclastically produced directed penetrative texture or structure commonly involving a family or set of S-surfaces; cataclastic foliation. May be visible megascopically or only microscopically. Does not necessarily involve compositional layering or lamination, although many examples do show such layering."

The division of cataclastic rocks in the Ospwagan Lake area into the three subunits, is in part a measure of the degree of cataclasis and recrystallization-neomineralization. All cataclastic rocks within the study area are mylonites, blastomylonites or mylonite gneisses, and of these three categories, mylonite gneiss is the most abundant. Thus, for mylonite gneiss and blastomylonite, Higgins shows the following relationships:


Parent rock
increasing recrystallization-neomineralization
Mylonite gneiss (or schist)
decreasing cataclasis
Blastomylonite
Mylonite gneiss (or schist)

Mylonite gneiss (A9a)

Mylonite gneiss is defined by Higgins as:

> "A coherent rock intermediate between a protomylonite or coarse mylonite and a crystalline gneiss (or schist) because its texture is the result of combined cataclastic and crystalloblastic processes. Augen structure is characteristic, the augen generally being porphyroclasts or crushed aggregates of felsic minerals. The augen, although commonly recrystallized, preserve evidence of cataclastic texture by their shapes and by the crush trails commonly associated with them; the surrounding groundmass has been recrystallized and (or) neomineralized, although it also may show palimpsest cataclastic texture. Most of the porphyroclasts are larger than 0.5 mm, and they make up more than about 30 per cent of the rock."

The quartzo-feldspathic mylonite gneiss (A9a) was derived principally from the grey _lit_-_par_-_lit_ gneisses. Gradations from the non-cataclastic rock into the major fault zone can be followed at several locations along the southeastern shore of Ospwagan Lake. One striking feature associated with the production of these rocks is the introduction of potash. As noted above in the description of the _lit_-_par_-_lit_ gneisses (A1), potassium metasomatism and cataclasis appear to have been concurrent processes in this area. The mineral modes of cataclastic and non-cataclastic gneisses, based on a thousand point counts of stained rock slabs, are presented in Table 6. The mylonite gneiss is a grey to dark grey, medium-grained quartz-plagioclase-biotite and/or muscovite gneiss with pale pink or white potassium feldspar porphyroclasts (Plates 9 and 10). Weathered surfaces are grey or pale buff. Fluxion structure is generally well developed and is seen in thin section to consist of highly strained 'ribbons' or fine-grained recrystallized polygonal grains of quartz and secondary micas. The latter have a preferred orientation. This groundmass is deflected around ovoid or lenticular microcline augen which range from several millimetres to 3 cm or more in length (Plate 11). Some porphyroclasts are rimmed by antiperthite, indicating disequilibrium of the assemblage. Less commonly, porphyroclasts consist of plagioclase or mineral aggregates. Augen greater than 1 cm in length make up between 5 and 20 per cent of the rock.

Table 6. Modes (in per cent) of cataclastic and non-cataclastic gneisses in the Ospwagan Lake area

	Non-cataclastic gneisses			Cataclastic gneisses			
	1	2	3	4	5	6	7
Potassium feldspar	1.7	0.3	2.4	10.3	18.1	12.7	23.0
Plagioclase	55.2	36.3	61.0	55.4	45.4	47.8	38.1
Quartz	32.4	37.9	29.4	28.2	22.8	20.1	26.3
Biotite and/or muscovite	8.7	19.4	6.5	5.3	13.1	19.1	12.4
Garnet	1.8	6.0		0.2			
Other	0.2	0.1	0.7	0.5	0.6	0.3	0.3

Sample descriptions:

1. Medium-grained grey gneiss (18-72-500) on Provincial Road 391 near Paint Lake turn-off; 500 m or more from cataclastic fault zone.

2 and 3. Medium-grained grey gneiss (18-72-200, 18-72-202) on southeast shore of Ospwagan Lake, approximately 200 and 500 m distant from recognizable cataclastic rocks.

4-7. Grey mylonite gneiss (18-72-433, 18-72-273, 18-72-283 and 18-72-278) from cataclastic fault zone on east shore of Ospwagan Lake.

Blastomylonite (A9b)

Blastomylonite is defined by Higgins (1971) as:

> "A coherent rock intermediate between medium- to fine-grained mylonite or ultramylonite and a crystalline schist or gneiss because its texture is the result of combined cataclastic and crystalloblastic processes. It is not produced by later recrystallization or neomineralization of a previously mylonitized rock; cataclasis and neomineralization-recrystallization are concurrent, which produces a rock in which crystalloblastic texture appears to have overprinted the basic mylonite texture. Porphyroclasts in blastomylonites are generally smaller than about 0.5 mm and may show recrystallization. They make up less than about 30 per cent of the rock."

Blastomylonite in the map-area was derived from both grey *lit-par-lit* gneiss and metasedimentary rocks. The distinction between this type of cataclastic rock and the laminated metasediments is particularly difficult in the field, because of the absence of positive criteria identifying the laminae as primary structures. The laminae in the metasediments and blastomylonites generally lie parallel to the regional strike of the fault zones.

Blastomylonite (A9b), which is distinguished from mylonite gneiss in the field by the lack of visible porphyroclasts, is intercalated in minor amounts with mylonite gneiss (A9a) along the western shore and adjoining islands and reefs of Ospwagan Lake. A prominent exposure of blastomylonite occurs on a reef west of Niven Point. At this locality the blastomylonite (Plates 8 and 12) strongly resembles the meta-greywackes and/or tuffs immediately to the east, from which it was probably derived. The rock breaks readily along the well developed fluxion structure, and exhibits numerous intrafolial folds, boudinage structures and conjugate kink bands. In thin section the blastomylonite appears as a fine-grained mixture of recrystallized quartz, feldspar and strongly oriented biotite and muscovite (Plate 13). The quartz is strained and in places forms "ribbons". Rare plagioclase porphyroclasts, with trails of finer material, attest to its cataclastic nature. The rock weathers brownish grey or buff.

Mylonite (A9c)

The term mylonite (Greek: mylon, a mill) as defined here by Higgins is a modification of Lapworth's (1885, p. 559, *in* Higgins, 1971) original definition of the rock:

> "A coherent microscopic pressure-breccia with fluxion structure that may be megascopic or visible only in thin section and with porphyroclasts generally larger than 0.2 mm. These porphyroclasts make up from about 10 to about 50 per cent of the rock. Mylonites generally show recrystallization and even new mineral formations (neomineralization) to a limited degree, but the dominant texture is cataclastic."

The mylonite gneiss and blastomylonite are metamorphic tectonites in the sense that recrystallization and neomineralization accompanied the process of cataclasis. The development of cataclastic rocks without these concurrent metamorphic processes appears to have been practically non-existent in the Ospwagan Lake area. However, within the major fault zones, three localities were revealed, through thin section examination, where the process of cataclasis appears to have been dominant and where the material was sufficiently fine grained for the rocks to be termed mylonite. The formation of this third subunit (A9c) to differentiate true mylonite from other cataclastic rocks serves here only to pinpoint the location of such rocks. Mylonite may be more extensive but cannot be readily identified in the field.

Mylonite occurs on the west shore of a small lake near the southern boundary of the map-area, just east of the Taylor River, and also at several localities on the west shore of Ospwagan Lake. In outcrop it forms inconspicuous thin irregular zones, parallel to the cataclastic foliation (Plate 14). The rock consists of a finely brecciated quartzo-feldspathic groundmass, interspersed with coarser quartz, feldspar and aligned mica fluxion bands (Plate 15). The rock commonly contains low grade metamorphic minerals which include epidote, chlorite and calcite. It is possible that these narrow mylonite zones represent reactivated planes of movement within the pre-existing cataclastic fault zones.

Subarea B - Churchill province

Subarea B lies to the northwest of subarea A, and constitutes approximately four-fifths of the map-area. Three main units (B1-B3) have been recognized, comprising garnetiferous paragneiss, associated gneissic granodiorite, and quartz monzonite (Table 1). Mafic dykes, which cut all other units in the area make up the fourth and youngest unit (B4). The foliation in the major units (B1-B3) has a dominant northeasterly trend, and variable dips which approach the horizontal near the centre of the region. Outcrops are sparse except for good shoreline exposure along several sections of the Burntwood River, and a 3 km long ridge of outcrop north of Birch Tree Brook. Geological contacts have been approximated or assumed on the basis of the limited bedrock exposure, and a combination of air photo and aeromagnetic interpretation.

Grey, garnetiferous biotite (-cordierite-sillimanite) paragneiss (B1)

This is the most abundantly exposed rock type in subarea B and is assumed to underlie the greater portion of the subarea. The best exposures occur along the Burntwood River and on the ridge north of Birch Tree Brook. Elsewhere, the rock is exposed on isolated knolls which protrude through the clay covered plateaux or peat bogs.

The gneiss is characterized by mauve coloured garnets, which range between 0.2 and 2 cm in diameter, and normally comprise 5 to 20 per cent of the rock. The colour, size range and abundance of these garnets distinguish unit B1 from the grey biotite lit-par-lit gneisses (A1) in subarea A. Although primary sedimentary features are lacking, unit B1 has been termed a paragneiss for the following reasons:

1) its pelitic composition suggests derivation from a thick argillite and greywacke sequence;
2) similar rocks extend over a wide area to the west, including the Sherridon-Snow Lake region, where they are known as the Nokomis Group of the Kisseynew gneissic complex. These rocks in the latter area show definite evidence of a sedimentary origin (Bailes, 1971).

In the northern part of the map-area the paragneisses are intensely deformed and display both similar and concentric styles of folding which are probably related to two or more periods of deformation and recrystallization (Plate 16). The gneiss in this area is migmatitic, with mobilizate constituting 20 to 50 per cent of the rock. South and east of the Burntwood River the paragneisses are evenly layered and minor folds are generally lacking. In these regions the mobilizate commonly constitutes less than 25 per cent of the rock. Contacts with the larger 'domal' gneissic granodiorite and quartz monzonite bodies (B2) are gradational. The quartz monzonite body (B3) west of Ospwagan Lake has sharp intrusive contacts with the gneiss.

The paragneiss is a light to dark grey, fine to medium-grained pelitic gneiss with granoblastic texture. Plagioclase, quartz, biotite and garnet are the major constituents. Mineral modes, each based on a thousand point counts on stained slabs, are presented in Table 7. The modes of the gneissic granodiorite and quartz monzonite described in the following sections are included for comparison. Cordierite and sillimanite were noted in about half the thin sections studied, from localities

Table 7. Modes (in per cent) of garnetiferous paragneiss (B1), gneissic biotite-quartz monzonite and granodiorite (B2) and gneissic hornblende-quartz monzonite (B3)

	B1			B2						B3	
	1	2	3	4	5	6	7	8	9	10	11
K-feldspar			7.8	24.2	24.6	20.4	16.7	16.2	7.6	36.9	36.1
Plagioclase	47.4	33.2	41.1	36.2	32.7	35.7	40.1	41.1	46.8	27.1	19.2
Quartz	34.1	31.9	25.3	22.3	27.5	38.8	25.0	20.6	19.4	27.3	36.6
Biotite*	11.8	20.8	16.8	14.2	12.3	4.7	17.6	17.6	25.9		
Hornblende**										7.6	8.2
Garnet	6.6	14.0	9.0	2.6		0.3	0.1	4.4		0.5	
Other	0.1	0.1	0.1	0.7	3.0	0.1	0.4	0.1	0.2	0.5	0.1

* Includes minor hornblende and/or muscovite and chlorite.

** Includes minor biotite and/or chlorite.

Sample descriptions:

1. Fine-grained grey gneiss containing 2 mm garnets (18-72-469); Manasan River near east map-boundary.
2. Medium-grained dark grey gneiss containing 2-3 mm garnets (18-72-533); 500 m west of the Taylor River.
3. Fine and medium-grained dark grey gneiss containing 1-2 mm garnets (18-72-516); north of Birchtree Brook.
4. Medium-grained grey, gneissic quartz monzonite (18-72-551); 700 m southwest of Jackpine Falls.
5. Medium-grained pinkish grey, gneissic quartz monzonite (18-72-537); 3 km west of the Taylor River.
6. Medium-grained pink, gneissic quartz monzonite (18-72-540); 5 km west of the Taylor River.
7. Medium-grained grey gneissic granodiorite (18-72-561); 1.6 km northeast of Burntwood River elbow.
8. Medium-grained grey gneissic granodiorite (18-72-555); 2.5 km north of Jackpine Falls.
9. Medium-grained grey gneissic granodiorite (18-72-531); 2 km north of Birchtree Brook.
10. Coarse-grained pink gneissic quartz monzonite (18-72-246); west shore of Ospwagan Lake.
11. Coarse-grained pink gneissic quartz monzonite (18-72-267); west shore of Ospwagan Lake. Chlorite has partially replaced hornblende.

distributed throughout the area. In the north, where the gneisses are migmatitic in character, deep blue subhedral cordierite and coarse garnets are prominent constituents of the quartzo-feldspathic mobilizate (Plate 17).

Under the microscope the paragneiss is seen to consist of 0.2-0.5 mm, anhedral, equant, interlocking grains of sodic plagioclase and quartz. Plagioclase (An_{18-25}) is clear and displays albite twinning but is without visible zoning. Quartz is also free of inclusions but is mildly strained and commonly occupies embayments in the plagioclase. Deep brownish red, subhedral biotite, between 0.1 and 1 mm in length, exhibits a preferred orientation which imparts a foliation to the rock. Porphyroblastic euhedral to subhedral garnets of the order of 5 mm in diameter are scattered throughout. Deformed S-shaped garnets, adjacent to a younger generation of euhedral garnets, were noted in an outcrop on the northern boundary of the map-area. Commonly, anhedral cordierite is spatially associated with the garnets. In places the cores of the cordierite are filled with swirled masses of minute euhedral sillimanite needles. Textural relations indicate a paragenetic sequence in which garnet, cordierite and sillimanite were formed at the expense of plagioclase, quartz and biotite.

Gneissic biotite-quartz monzonite and granodiorite (B2)

This unit comprises a variety of homogeneous, medium-grained and weakly foliated, holocrystalline felsic rocks. The rocks are grey or pink on fresh surfaces and weather light grey, whitish or pale pink. The bodies of quartz monzonite and granodiorite have an irregular but overall northeasterly trend, and are thought to have been derived, in part, through anatexis from the garnetiferous paragneiss (B1). They outcrop along the

Burntwood River in the region of Jackpine Falls and Upper Kepuche Rapids, in the southwestern portion of the map-area, and north of Birch Tree Brook. Other sparse exposures mapped north and east of the Burntwood River are widely separated, leaving a large degree of uncertainty as to the extent of this unit. The large body in the southwestern part of the area, comprises the northeastern continuation of a 'pink, porphyroblastic granodiorite-quartz monzonite' unit at the west end of the Burntwood Project area (McRitchie, 1971; Figure 4-2) and conforms closely to the description of unit 10 in Table 3-1 for the Burntwood Project, western area (McRitchie et al., 1972). This body is displaced in a sinistral sense along the northeast-trending Burntwood River fault.

Contacts of the quartz monzonite-granodiorite are rarely exposed but, where visible, are either gradational or sharply intrusive. The gradation from the garnetiferous paragneiss into quartz monzonite can be observed in the vicinity of Jackpine Falls. Here the gneiss becomes increasingly homogeneous and granitic in appearance. A garnetiferous skialithic quartz monzonite, which outcrops near the contact with the homogeneous paragneiss, consists of grey gneissoid rafted remnants, suspended in and enveloped by a whitish granitic material. The foliation, in this region is shallow and locally approaches the horizontal in both the garnetiferous paragneiss and gneissic quartz monzonite. These attitudes suggest that, in this location, the paragneiss forms a shallow northeast plunging anticlinal structure overlying the felsic rocks. Elsewhere in the map-area, foliations dip steeply and strike dominantly northeast.

Thin section examination indicates that the unit mainly consists of sodic plagioclase, microcline, quartz and weakly oriented brown biotite. Brownish green hornblende is present in varieties approaching quartz diorite in composition as, for example, in sample 18-72-531 (column 9) in Table 7. In this sample, hornblende accounts for nearly half of the mafic content. Fresh or mildly sericitized anhedral plagioclase (An_{21-28}), showing albite twinning, comprises between 30 and 40 per cent of the rock. In varieties closer to a quartz diorite in composition, the anorthite component and total plagioclase content are increased by 5 and 10 per cent respectively. Compositional zoning, although rare, indicates a normal 'magmatic' growth trend for plagioclase. Crystal cores are as much as 5 per cent more calcic than the rims. The pink colouration associated with some parts of the unit, particularly near the south boundary of the map-area, appears to be caused by minute dusty inclusions of hematite in the plagioclase. This appears to be a secondary feature, occurring in retrogressively altered quartz monzonite in which the mafic constituents are chloritized. Microcline forms anhedral grains which comprise between 15 and 25 per cent of the rock. Some crystals are in contact with myrmekitic intergrowths and show sutured margins where in contact with quartz. Relict garnet occurs as coarse irregular grains which are dispersed throughout the rock at many localities (Table 7). Apatite, zircon and magnetite are common accessories. Magnetite is a prominent constituent in a thinly banded variety of gneissic granodiorite which outcrops close to the northern boundary of the map-area.

Gneissic hornblende-quartz monzonite (B3)

This unit forms a lens-shaped stock, approximately 1.5 km by 10 km in size, immediately to the west of Ospwagan Lake. The body trends northeast and is presumed to intrude the garnetiferous paragneiss (B1) although intrusive contact relationships are observed only along its eastern margin. Elsewhere the body is poorly exposed, except for centrally located outcrops near its northern and southern extremities. The outline of the stock has been defined on the basis of a generally positive topographic and aeromagnetic expression.

The quartz monzonite is considered to be a truly plutonic rock. It is a pink, coarse-grained, locally porphyritic and weakly foliated rock, in which hornblende is the dominant mafic constituent. It is at least 10 per cent richer in potassium feldspar than the medium-grained quartz monzonitic rocks (B2) to the west (Table 7). It is therefore texturally and compositionally distinctive.

At its northeast and southwest ends, the body has a sharp intrusive contact against the garnetiferous paragneiss (B1). The central portion of the quartz monzonite, exposed on the west shore of Ospwagan Lake, is in sheared contact with grey lit-par-lit gneiss (A1) and cataclastic rocks. The quartz monzonite at this locality, has a strong cataclastic foliation parallel to the main cataclastic fault zone. This foliation dips steeply to the southeast and contains thin seams and stringers of white quartz. The quartz monzonite is cut by narrow white pegmatite dykes which trend predominantly northwest. Along the eastern contact, dark grey, lens-shaped, gneissic inclusions commonly appear.

The quartz monzonite has a holocrystalline granular texture and is composed of anhedral microcline, perthite, sodic plagioclase and quartz, together with hornblende and/or biotite and chlorite. The plagioclase is weakly zoned, and ranges in composition between An_{30} and An_{38}. The pink colouration of the rock is due to dusty inclusions of hematite in the plagioclase. In some grains there is a preferred concentration of hematite in alternating albite twin lamellae.

Retrogressive metamorphism, associated with the cataclasis in the eastern part of the body, has caused sericitization of the plagioclase, and the production of greenish brown biotite and green penninite chlorite. Hornblende is absent. The coarse felsic constituents are strained, bent and fractured, and fractures in the rock are filled with epidote. Accessory magnetite has been partially replaced by pyrite.

Diabase dykes (Mackenzie Swarm) (B4)

The three northwesterly trending dykes, in the northeastern part of the map-area, have been inferred from aeromagnetic data (Federal-Provincial Map 2593G). The intrusions are not exposed in this clay covered area, but give rise to positive linear magnetic anomalies, which can be traced continuously for some distance across the Churchill province to the northwest and the Wabowden subprovince to the southeast. A whole rock potassium-argon date on a sample from a diabase dyke immediately to the northwest of the map-area, on strike with one of the inferred dykes within the map-area, produced an age of 865 ± 99 m.y. (Wanless _et_ _al_., 1968; G.S.C. sample 67-94). Ages of 1130 ± 135 m.y. (Wanless _et_ _al_., 1966; G.S.C. sample 65-102) and 1095 ± 15 m.y. (Wanless _et_ _al_., 1968; G.S.C.

sample 67-95) were obtained from samples of similar northwest-trending diabase dykes at Mystery Lake and in the Superior province, east of the present map-area.

The dykes appear to cut all other rock units in the area. They show no offset where they cross the cataclastic fault zones, suggesting that movement in these zones had ceased prior to injection of the dykes.

REGIONAL METAMORPHISM

Dynamothermal metamorphism has affected all rocks in the area with the exception of the youngest generation of pegmatites. Metamorphism of the diabase dykes is unknown as these dykes are not exposed in the map-area. Mineral assemblages diagnostic of certain metamorphic facies are listed in Table 8 and discussed below. The assemblages characteristic of the greenschist and lower amphibolite facies are present in the supracrustal volcano-sedimentary and cataclastic rocks (A2-A9), whereas middle and upper amphibolite facies assemblages are represented in the pelitic gneisses (A1 and B1) and sialic rocks (B2 and B3).

Subarea A

The lowest facies of metamorphism are preserved in the picritic flows and overlying sediments. The coexistence of tremolite-actinolite with chlorite, and the absence of hornblende, places the meta-picrites (A2) in the greenschist facies. Clastic and/or recrystallized sodic plagioclase (An_{22-34}) and microcline, together with minor quantities of epidote, zoisite, calcite, chlorite and sericite, limits the metasedimentary rocks (A4 and A5) to the same facies.

The effect of regional metamorphism on the ultramafic rocks (A7), subsequent to serpentinization, appears to have been minimal. Minor chlorite and calcite have locally replaced serpentine in the former intercumulate portion of the rock. The foliated granitic pegmatites (A8) which intrude the volcanic rocks contain minor amounts of chlorite and epidote in addition to perthite, microcline, quartz and muscovite. Thus both the ultramafic and granitic intrusive rocks contain greenschist facies mineral assemblages.

Table 8. Mineral assemblages and metamorphic facies represented in the Ospwagan Lake area

Mineral assemblages	Map-units	Metamorphic facies	
Subarea A Tremolite/actinolite Chlorite Olivine/iddingsite (Hornblende absent)	A2	Greenschist	SUPRACRUSTAL ROCKS
Serpentine Olivine Chlorite Calcite	A7		
Sodic plagioclase Microcline Epidote/zoisite Calcite Chlorite/sericite	A4,A5,A9		
Blue-green hornblende Intermediate plagioclase (Epidote absent)	A3, A6	Lower amphibolite	
Green hornblende Pyroxene (relict) Sillimanite (rare) Cordierite (rare) Microcline (porphyroblastic) (Absence of muscovite, andalusite)	A1	Upper amphibolite and retrograded equivalents	PELITIC GNEISSES/SIALIC ROCKS
Subarea B Plagioclase Quartz Biotite Pyralspite (almandine) Cordierite Sillimanite Muscovite (rare) (Andalusite absent)	B1	Middle amphibolite	
Plagioclase Quartz Microcline Biotite Hornblende (Orthoclase absent)	B2, B3		

Greenschist facies metamorphism is also characteristic of the zones of cataclasis (A9) in which chlorite, sericite, epidote and zoisite have partially replaced biotite, minor hornblende and plagioclase. This appears to be a retrogressive mineral assemblage, developed during cataclasis of the pelitic gneisses (A1) and metasedimentary rocks (A4 and A5).

The pillowed basalt (A3) contains mineral assemblages which reflect a higher degree of regional metamorphism than the underlying meta-picrites. Blue-green hornblende, intermediate plagioclase (An_{36-60}) which exhibits inverse zoning, and the absence of epidote, are all considered to be indicative of the lower amphibolite facies. This discrepancy in metamorphic grade between the meta-picrite/metasedimentary successions and the meta-basalt may be due to control by their respective compositions, in which case the meta-basalt may be at a lower metamorphic grade than is suggested by the mineral assemblage.

The grey lit-par-lit gneiss and porphyroblastic gneiss (A1) locally contain abundant pegmatitic material. These pelitic rocks form the greater portion of subarea A, southeast of the volcano-sedimentary supracrustal group, but only in a few places contain minerals diagnostic of the metamorphic grade. Upper amphibolite facies conditions of metamorphism are indicated however by the incipient anatexis, the local appearance of exclusively green hornblende, the rare occurrence of cordierite and sillimanite, and the absence of muscovite and andalusite. The metamorphism possibly reached the granulite facies locally, as indicated by the rare occurrences of hypersthene and diopside in more mafic portions of the gneisses or included amphibolite lenses.

The presence of porphyroblastic microcline, which occurs with increasing regularity towards the northwest cataclastically deformed margin of the gneisses, and the relict appearance of the pyroxene, together indicate a possible retrogressive phase of metamorphism.

Subarea B

The garnetiferous paragneiss (B1) contains mineral assemblages corresponding to the middle amphibolite facies of low pressure regional metamorphism, specifically the assemblage plagioclase-quartz-biotite-pyralspite garnet-cordierite-sillimanite and rare muscovite. There is some evidence to suggest that the grade of metamorphism increases in a northwesterly direction. This is demonstrated by an increase in the degree of migmatization, and proportion of pegmatitic mobilizate present in the gneiss, towards the northwest corner of the map-area.

Within the amphibolite facies, the general occurrence of cordierite and sillimanite and the absence of staurolite and kyanite is indicative of low-pressure metamorphism. This mineral assemblage corresponds to the 'andalusite-sillimanite type' of Miyashiro (1958, in Miyashiro, 1968) described for the Ryoke-Abukuma metamorphic belts of Japan. Regional metamorphism of this type operated under a steep geothermal gradient at shallow depths during orogenesis.

The granodiorite and quartz monzonite bodies (B2 and B3) contain the assemblage plagioclase-quartz-microcline-biotite and/or hornblende which is stable under middle amphibolite facies conditions.

Retrogressive metamorphism of the amphibolite facies assemblages is evident along the northwest-trending Burntwood River fault, where epidote and calcite occur locally in brecciated or heavily fractured exposures of gneiss along the river.

Discussion

The highest grade of regional metamorphism is present in the lit-par-lit gneiss (A1) of subarea A, which may locally approach the granulite facies. Both structural data and the grade of metamorphism in the Ospwagan Lake and Setting Lakes areas (Rance, 1966) support the contention that these pelitic gneisses are the oldest rocks in the area. Cranstone (in Coats et al., 1972) has proposed that they are retrograded equivalents of the Archean Pikwitonei province granulites, which were metamorphosed during the Kenoran orogeny.

The distinctly lower grade metamorphism prevailing in the supracrustal volcano-sedimentary and associated intrusive rocks (A2-A8) appears to have resulted from one main event. This belt of greenschist to lower amphibolite facies rocks occurs along the southeast margin of the middle amphibolite facies garnetiferous paragneisses and quartz monzonitic rocks (B1-B3) of subarea B. The overall increase in metamorphic grade in a northwest direction, from greenschist in the supracrustal rocks of subarea A to middle amphibolite facies in the pelitic gneisses of subarea B, may be related to a single period of dynamothermal metamorphism. Cataclasis however, appears to have postdated this period of metamorphism, and was accompanied by retrogressive metamorphism.

Absolute ages along the Manitoba nickel belt, as plotted on the Isotopic Age Map of Canada (Geological Survey of Canada, Map 1256A, 1970), range from 2035 m.y. to 1515 m.y. The potassium-argon method, performed on whole-rock and mineral specimens of gneisses and granitic rocks, reflects Hudsonian ages for both intrusive and metamorphic events.

STRUCTURAL GEOLOGY

Deformation has affected all units within the map-area, with the exception of the youngest pegmatite dykes and northwest-trending diabase intrusions. The most prominent structural features are the northeast-trending cataclastic zones which form part of the Manitoba nickel belt fault system. This northeasterly trend persists in the foliation of the pelitic gneisses of subareas A and B and the supracrustal rocks of subarea A.

The map-area has been divided at major geological boundaries into three structural domains. In subarea A, the pelitic gneiss (A1) and included amphibolite (A6a) comprise structural domain 1, and the cataclastic zones (A9) and supracrustal rocks (A2-A8) make up structural domain 2. Structural domain 3 corresponds to subarea B and encompasses the pelitic gneiss (B1) and the anatectic and intrusive felsic rocks (B2 and B3). Relevant structural data are presented on contoured equal-area stereographic projections for each of the three structural domains (Figures 9, 10 and 11).

In structural domain 1, poles to metamorphic layering and foliation indicate an average planar attitude of 040/80SE (Figure 9A). The same attitude is found for the cataclastic foliation and layering in domain 2 (Figure 9B). Poles to metamorphic layering and foliation in domain 3 (Figure 9C) form a broad girdle in which a pole maximum indicates a predominant attitude of 055/vertical. The prominent girdle in Figure 9C is representative of cylindrical folding about northeasterly plunging axes. Minor fold axes in domain 3 (Figure 10C) plunge in the same general direction and are therefore assumed to be parallel with the larger scale

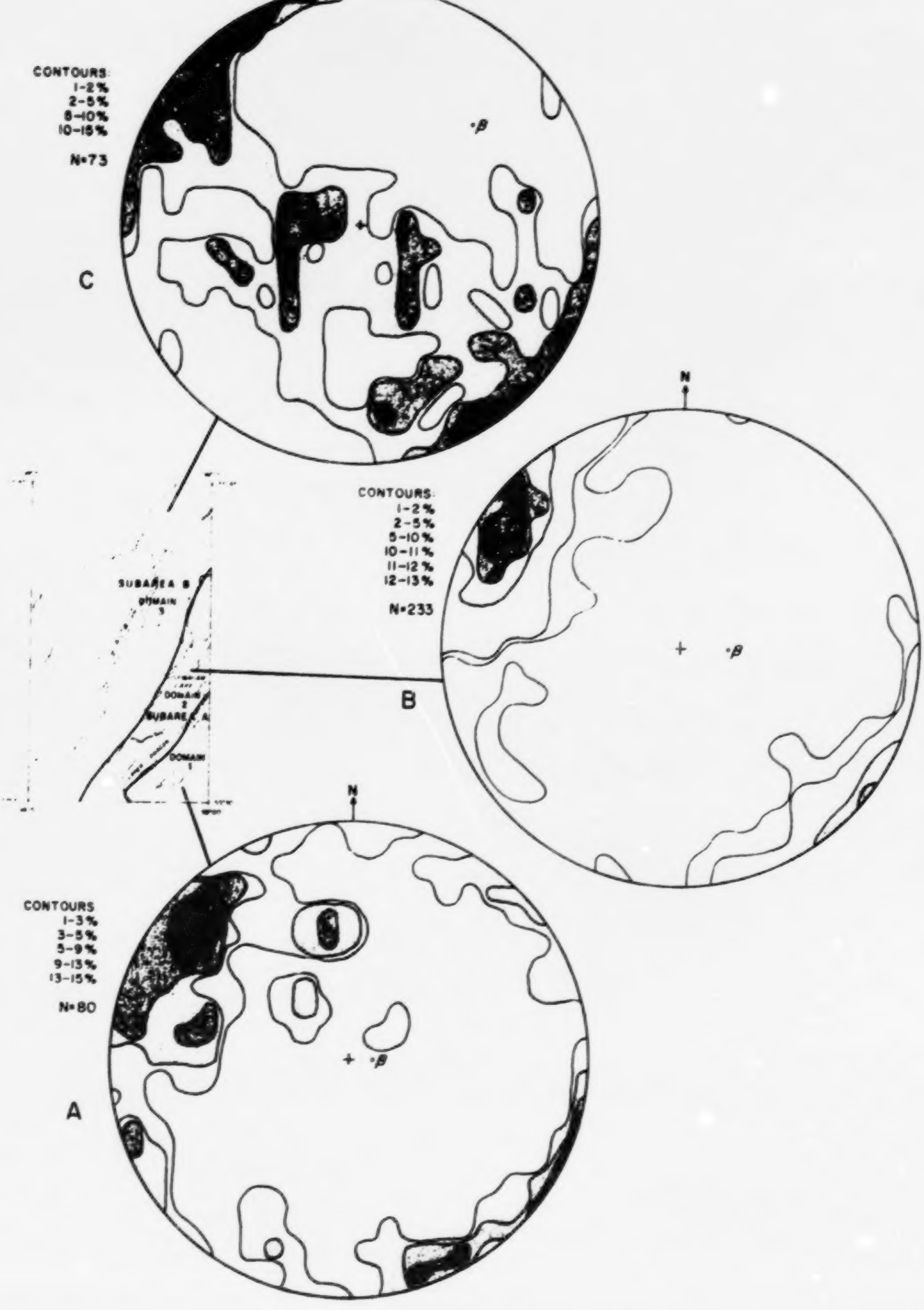

N
CONTOURS:
1-2%
2-5%
5-10%
10-15%
N=73
β
C
N
CONTOURS:
1-2%
2-5%
5-10%
10-11%
11-12%
12-13%
N=233
β
B
SUBAREA B
DOMAIN
3
DOMAIN
2
SUBAREA A
DOMAIN
1
N
CONTOURS
1-3%
3-5%
5-9%
9-13%
13-15%
N=80
β
A

FIGURE 9. Equal-area projections of poles to foliation and metamorphic layering; structural domains 1, 2 and 3.

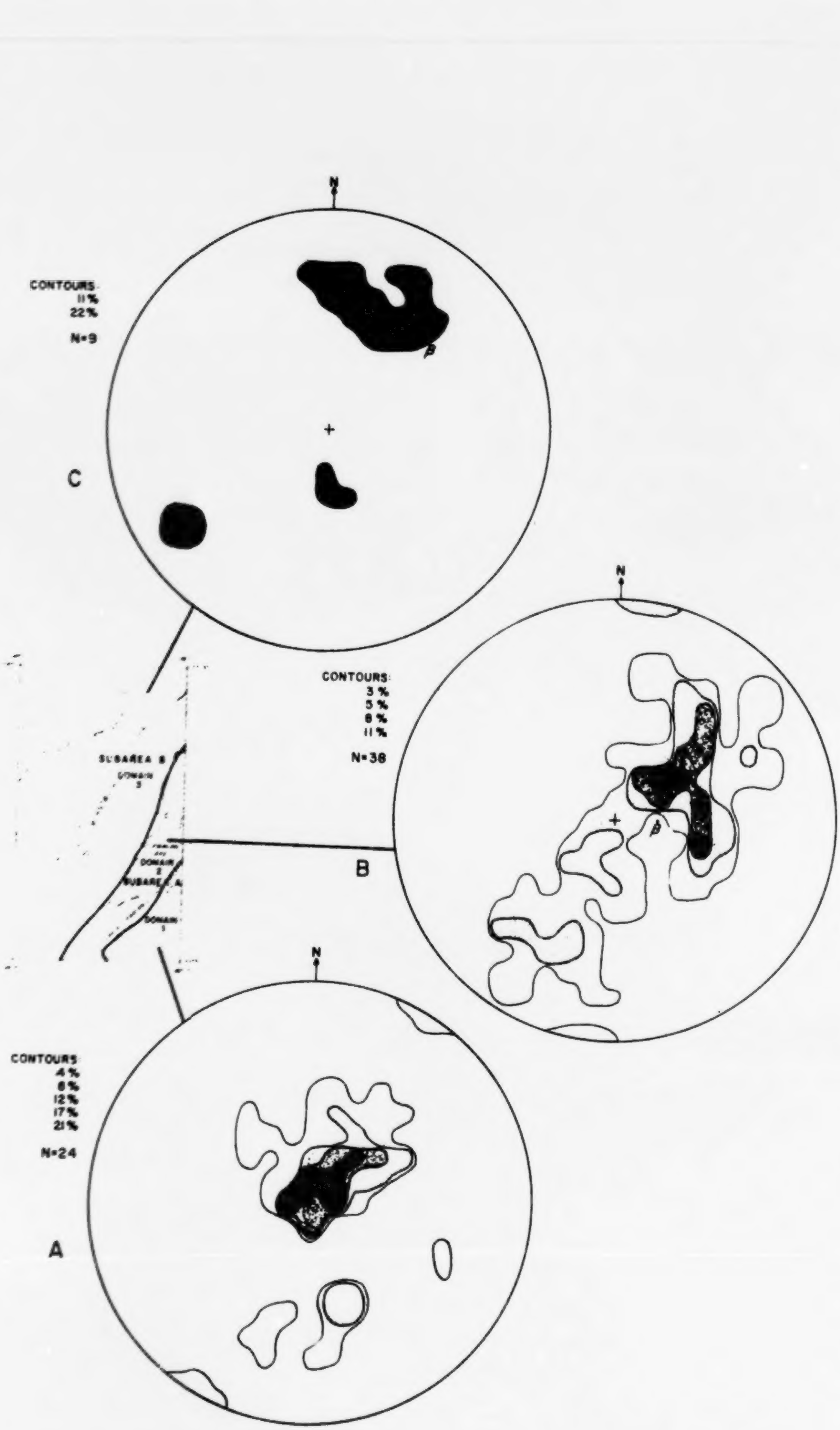

N
CONTOURS:
11%
22%
N=9
β
C
N
CONTOURS:
3%
5%
8%
11%
N=38
β
B
SUBAREA B
DOMAIN
3
DOMAIN
2
SUBAREA A
DOMAIN
1
N
CONTOURS:
4%
8%
12%
17%
21%
N=24
A

FIGURE 10. Equal-area projection of minor fold axes; structural domains 1, 2 and 3.

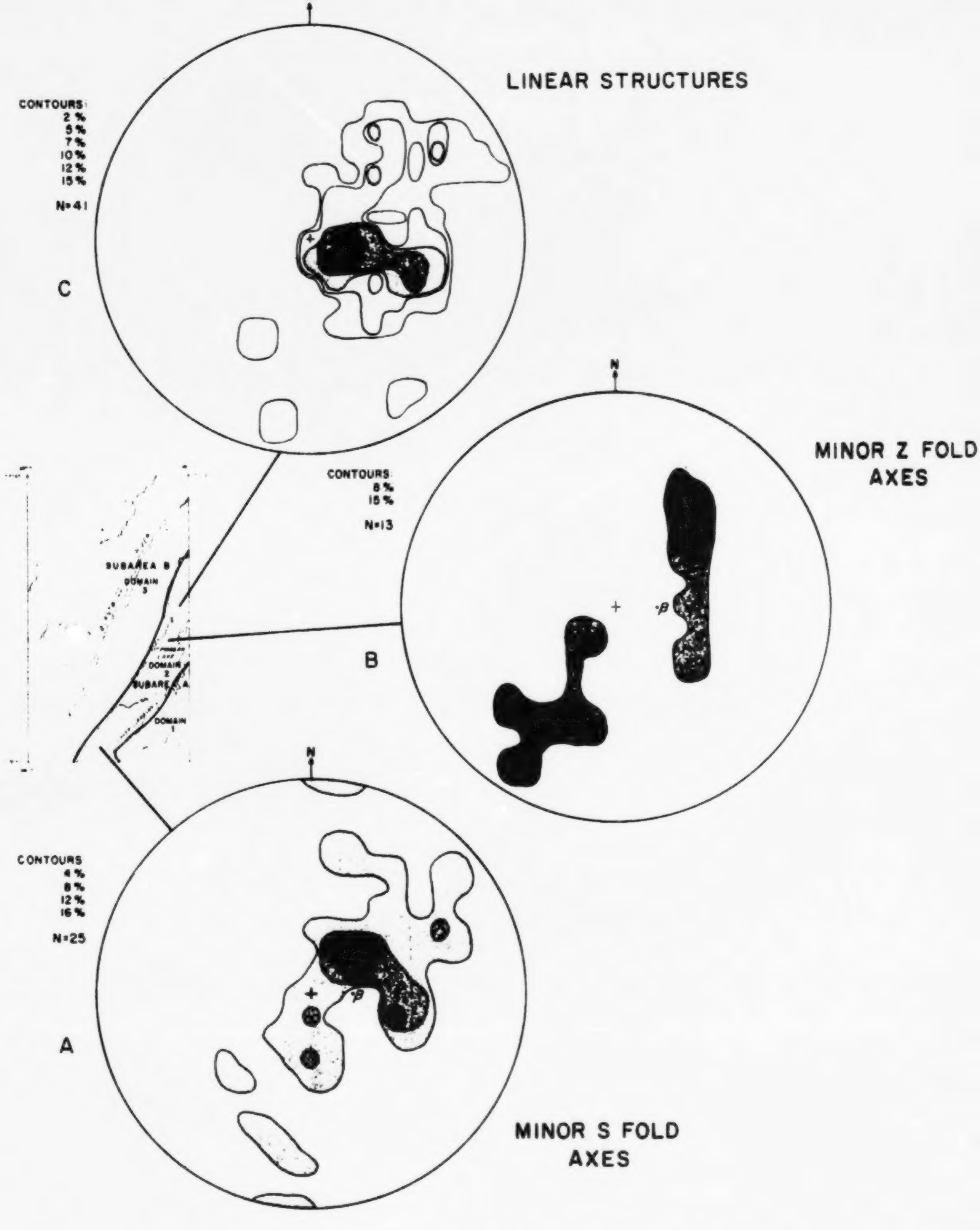

N
LINEAR STRUCTURES
CONTOURS:
2 %
5 %
7 %
10 %
12 %
15 %
N=41
C
SUBAREA B
DOMAIN
3
DOMAIN
2
SUBAREA A
DOMAIN
1
N
MINOR Z FOLD
AXES
CONTOURS:
8 %
15 %
N=13
β
B
N
CONTOURS
4 %
8 %
12 %
16 %
N=25
β
A
MINOR S FOLD
AXES

FIGURE 11. Equal-area projections of minor fold axes, linear structures; structural domain 2.

folding. Weaker, discontinuous girdles in Figures 9A and 9B are indicative of folding about almost vertical axes. In domain 1, minor fold axes (Figure 10A) cluster about the proposed girdle axis (β). Minor fold axes in domain 2 however (Figure 10B) lie on an almost continuous girdle which is perpendicular to the concentration of poles to foliation planes.

Small scale folds in the *lit*-*par*-*lit* gneiss (A1) in domain 1 are tight to isoclinal folds which deform the metamorphic layering. The folds range from 0.2 to 2 m in amplitude. Minor folds in structural domain 3 are defined mainly by anatectic *lit* in the garnetiferous paragneiss (B1) and are most abundant in the northern part of subarea B. The amplitude of the folds is generally less than 50 cm, and the folds commonly display a complex arrangement of symmetric or asymmetric concentric styles (Plate 16).

The cataclastic zones in domain 2 are characterized by minor intrafolial similar folds with amplitudes generally less than 1 m. These folds are refolded about more open concentric folds which have amplitudes of up to 5 m. Microcrenulations, which are commonly developed on the limbs of these concentric folds, are parallel to the fold axes. The tight intrafolial similar folds and the more open concentric folds exhibit both S and Z asymmetry. The girdle formed by these minor fold axes in Figure 10B results from a combination of local plunge variations of up to 30 degrees in a single outcrop, and a regional variation in plunge. A minor fold axis maximum within the girdle has an azimuth and plunge of 50 degrees. Separation of the S and Z fold axes indicates that the more numerous S axes retain the same distribution as the combined axes (Figure 11A), whereas the Z axes form two separate maxima (Figure 11B). Linear structures in domain 2 (Figure 11C), comprising microcrenulations and mineral lineations, form a partial girdle perpendicular to the maximum of poles to foliation planes. The maximum within this girdle coincides with the proposed near vertical fold axis (β) in Figure 9B.

Discussion

Regional folds in domains 1 and 2 appear to have developed about almost vertical axes, whereas large-scale folds in domain 3 plunge to the northeast. The shallow dips in domain 3 (Figure 9C) reflect the 'domal' form of the anatectic and intrusive quartz monzonitic bodies underlying the paragneiss. These felsic rocks were therefore regionally folded about northeast-trending axes which simultaneously affected the small-scale folding. In domain 3, the folding was followed by axial planar faulting, e.g. the Burntwood River fault. The fault is defined by an air photo lineament which also appears on recent imagery from the Earth Resources Technology Satellite (ERTS-1). The large quartz monzonite/granodiorite body south of the Burntwood River appears to be offset by the fault in a left lateral sense.

The relative age of the major cataclastic fault zones in domain 2 and the Burntwood River fault (domain 3) is unknown. Faulting in both domains postdated the regional folding. The cataclastic zones however, have undergone a 'plastic' style of deformation, involving small-scale drag folding and recrystallization, whereas the Burntwood River fault conforms to a 'brittle' type of deformation, characterized by fracturing and brecciation.

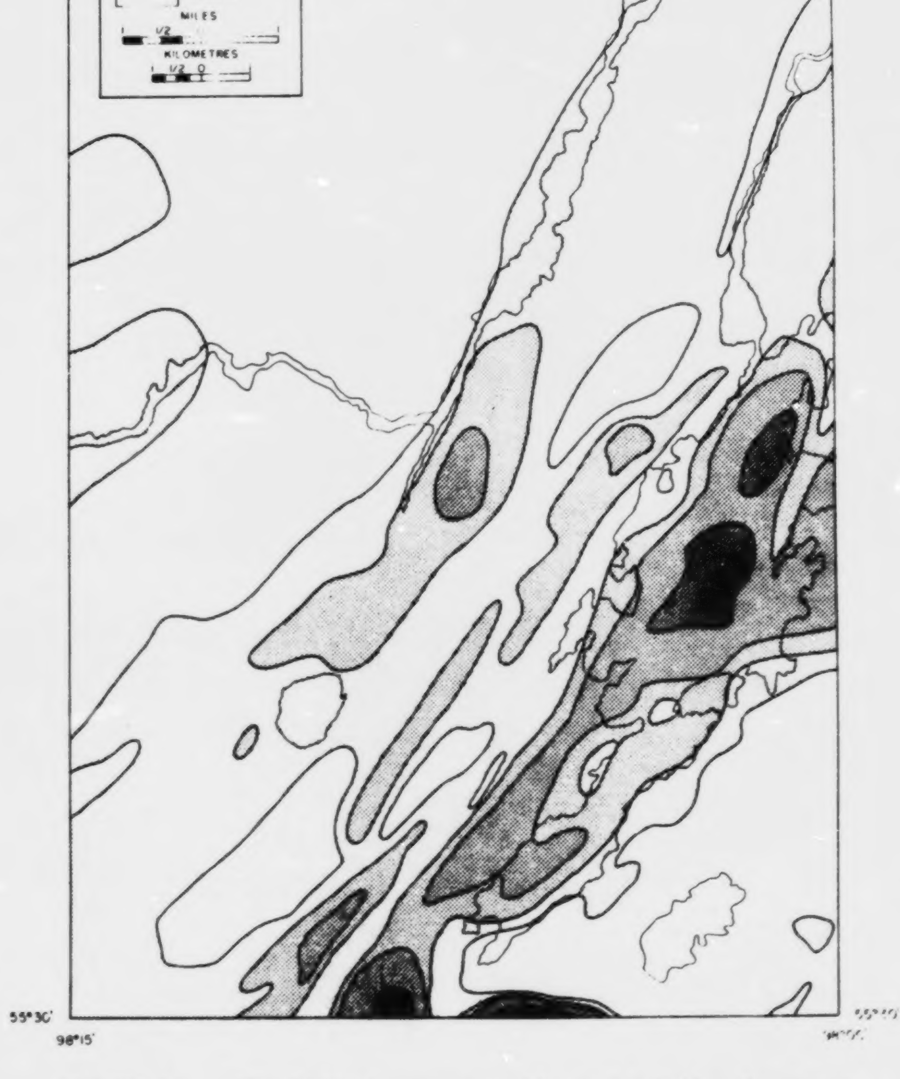
MAGNETIC CORRELATION

Introduction

The magnetic pattern in the Ospwagan Lake area (Figure 12) correlates closely with the surface geology and displays the same strong northeasterly trend. The magnetic intensity ranges from less than 2500 gammas to more than 5000 gammas, with generally higher values present in subarea A, particularly over the volcanic and ultramafic rocks. In contrast, much of subarea B displays a featureless magnetic pattern of low intensity. The main zone of cataclasis, along the west side of Lower Ospwagan Lake, follows a weakly defined linear magnetic "low".

Subarea A

The volcanic, sedimentary and ultramafic rocks in this part of the map-area (units A2-A9) give rise to a broad belt of high magnetic signature which contrasts with the uniformly low pattern of the grey lit-par-lit gneiss (A1). The greatest positive anomaly, with a peak in excess of 5000 gammas, occurs over the large ultramafic body (A7a) which underlies Lower Ospwagan Lake. The cause of the anomaly is the high magnetite content in this unit, resulting from excess iron released during conversion of primary ferromagnesian silicates to serpentine. Exposed serpentinized peridotite (A7a) contains up to 10 per cent magnetite. The meta-picrite (A2) and meta-basalt (A3) contain approximately 1-2 per cent magnetite, and give rise to moderate to high magnetic intensity of between 2500 and 4000 gammas. A strong positive anomaly, rising sharply to more than 5000 gammas, occurs on the southern map-boundary and coincides with



98°15'
55°45'
98°00'
55°45'
GAMMAS
>5000
4000-5000
3000-4000
2700-3000
2500-2700
<2500
MILES
1/2
KILOMETRES
1/2 0
55°30'
98°15'

FIGURE 12. Simplified aeromagnetic map of the Ospwagan Lake (East half) area (based on Federal-Provincial Aeromagnetic Map 7136G).

the orthopyroxene-garnet gneiss (A6b). Magnetite comprises less than 2 per cent of this unit, and it is probable therefore that the anomaly is in part caused by the ultramafic body which underlies Mid Lake.

Subarea B

The garnetiferous paragneiss (B1) displays a low, featureless magnetic signature of less than 2500 gammas, characteristic of the Kisseynew gneisses. Higher values of between 2500 and 3000 gammas occur over the biotite granodiorite and quartz monzonite (B2), and there is an increase of about 200 gammas for both units (B1 and B2) east of the Burntwood River fault. The hornblende quartz monzonite (B3) is similarly marked by a magnetic intensity which is 200 to 500 gammas above that of the paragneisses, although a small trough occurs in the anomaly pattern at the southwest end of the quartz monzonite body. Both the granodiorite (B2) and quartz monzonite (B3) generally contain less than 1 per cent magnetite.

The northwest-trending diabase dykes (B4) are well defined as narrow linear positive anomalies on the Federal-Provincial aeromagnetic map of the area (Map 7136G) but only one of the inferred dykes is visible on the simplified version of this map shown in Figure 12.

ECONOMIC GEOLOGY

Minor occurrences of sulphides are shown on the accompanying geological map. The mineralization comprises disseminated pyrrhotite and chalcopyrite, in north to northeast-trending rusty shear zones, and is restricted to the metasedimentary rocks and amphibolite around the shore of Lower Ospwagan Lake. The mineralization thus appears to be limited to host rocks bordering the ultramafic bodies which underlie Ospwagan Lake.

The best mineralized locality on Ospwagan Lake occurs at the northern tip of a peninsula on the east side of the lake. Here a 40 m long trench has been excavated along a north-trending, heavily rusted shear zone. The mineralized zone consists of coarse and finely disseminated pyrrhotite and traces of chalcopyrite, in schistose meta-greywacke (A4a). A grab sample from the dump assayed 0.66 per cent nickel and 0.13 per cent copper. Assays of samples from all other sulphide occurrences in the map-area yielded traces of nickel and copper. Sparsely disseminated pyrrhotite and chalcopyrite occur in meta-greywacke on the south shore of the same peninsula. Both of these sulphide localities occur between 100 and 200 m west of a serpentinized peridotite body (A7a), and stratigraphically underlie pillowed basalt (A3) which outcrops to the west.

Finely disseminated pyrrhotite and traces of chalcopyrite occur in sheared and rusted laminated mafic tuff (A4b) near the mouth of the Taylor River. Disseminated pyrrhotite was also found in sheared amphibolite (A6a) on a peninsula on the west side of Ospwagan Lake. Traces of pyrrhotite occur at intervals along the northeast-trending amphibolite body on the Taylor River. A 10 cm wide seam of pyrite and chert exposed over a 3 m length occurs at the north end of Niven Point. Assays of this material for gold and silver gave negative results.

There is little evidence of any surface exploratory work at these sulphide occurrences except for the trenching noted above. Little interest was shown in the Ospwagan Lake area until the discovery of the Thompson mine in 1956 by The International Nickel Company of Canada, Limited. Some gold exploration was apparently carried out prior to 1920 as Alcock (1921a) reports:

> "A number of claims have, however, been staked along Ospwagan Lake. Some of these are on small quartz veins traversing greenstone. One south of Niven Point is staked on a rusty zone in greenstone. The mineralization consists of pyrite, pyrrhotite, and some chalcopyrite in a shear zone about 2½ feet in width. A little work has been done on this claim but insufficient to show the extent of the mineralized zone."

Since 1956, geophysical surveys and exploratory diamond drilling have been carried out at a number of locations within the map-area. A summary of the exploration work submitted for assessment credit is listed in Table 9. This work is on 'open file' and available for inspection at the Manitoba Mines Branch, Winnipeg. The numbers listed in the first column of Table 9 refer to the claim groups outlined in Figure 13. The mining lease and claim areas currently held by The International Nickel Company of Canada, Limited are also shown in Figure 13.

Table 9. Summary of Assessment work (open file), Ospwagan Lake area (N.T.S. Reference NE9/630)

Reference No. on Figure 13	Date of Work	Name of Company	Name of Claims	Type of Work	Summary of Results
1	1957-1958	P.C.E. Explorations Limited	EVE claims	Electromagnetic and magnetic survey: Askania type vertical force magnetometer	3 continuous NNE trending conductors up to 2 km long and 1 weak discontinuous conductor, coincident with a NNE trending narrow magnetic anomaly, 1,000 to 2,000 gammas above background. Magnetic zone ascribed to "a band of magnetic gneiss" or a "basic intrusive mass"
2	1958	Gresham Exploration Limited, a subsidiary of the Rio Tinto Group	RUM claims	Airborne electromagnetic and magnetic survey	"Four short conductive zones of moderate-to-good conductivity were detected, and parts of all these showed direct magnetic correlation of the order of 30-50 gammas"
3	1961	Falconbridge Nickel Mines Limited	JESS and DEB claims	Magnetometer survey: Sharpe A-2 magnetometer "to examine a low magnitude, broad magnetic anomaly shown on the Manitoba Department of Mines areomagnetic releases"	3 narrow magnetic anomalies near centre of claim group. Largest anomaly 150 m long tending NNE, up to 1,500 gammas above background. Anomalies ascribed to "local surface effects". Regional areomagnetics (Map 2593G) indicates a broad, weak magnetic 'high' over claim group
4	1964-1966	Canadian Nickel Company	WET claims	12 d.d.h. (total footage, 4,275) to test regional aeromagnetic anomaly	Diamond drill core logs record biotite gneiss, amphibolite, pegmatite and "sulphide streaks" (in one hole only). Weak, linear NE trending areomagnetic anomaly (Map 2593G) coincides with magnetite-bearing gneissic granodiorite (map-unit B2)
5	1966	Canadian Nickel Company	LAKE claims	Magnetometer survey: Sharpe MF-1 fluxgate magnetometer "to outline any basic or ultrabasic intrusives or sulphide deposits"	A "flat magnetic intensity throughout the claim group". NW striking diabase dyke outlined

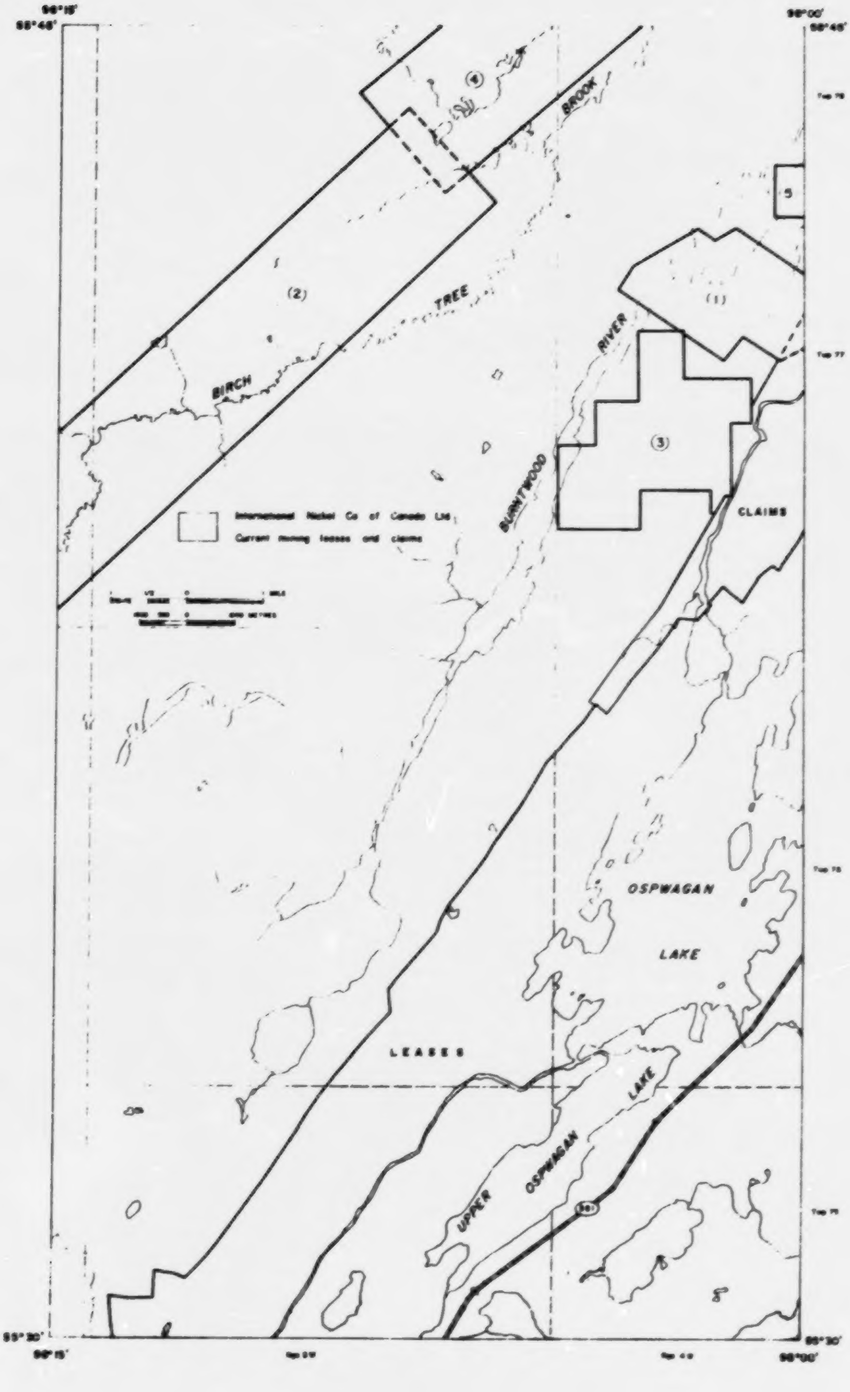

98°15'
55°45'
98°00'
55°45'
(4)
BROOK
5
(2)
TREE
(1)
RIVER
BIRCH
(3)
BURNTWOOD
CLAIMS
International Nickel Co of Canada Ltd
Current mining leases and claims
OSPWAGAN
LAKE
LEASES
UPPER OSPWAGAN LAKE
391
55°30'
98°15'
55°30'
98°00'

FIGURE 13. Cancelled claim group locations and current mining lease and claim area (June 1st, 1973) in the Ospwagan Lake map-area.

PLEISTOCENE DEPOSITS

Glaciation during the Pleistocene Epoch has left scoured and polished Precambrian bedrock. The azimuths of glacial grooves and striae vary from 80 degrees in the northern part of the map-area to 115 degrees in the south, indicating that the general direction of ice sheet advance was from the east, originating in the Patrician ice centre.

A hiatus during the recessional stage was marked by the deposition of boulders, pebbles and sand forming a terminal moraine 35 to 50 m thick (Plate 18). This moraine forms the flat-topped hills in the northwestern part of the map-area. Narrow, discontinuous, parallel terraces on the slopes of these deposits, are visible on air photographs, and are shown as raised beaches on the accompanying geological map.

Elsewhere, clay and silt, deposited in glacial Lake Agassiz, form low plateaux which are covered by open stands of spruce, jack pine and poplar. This lake bottom material also fills intervening depressions between bedrock hills, and is now covered by poorly drained peat bogs. Slumped clay ridges, up to 10 m high, line the west shore of Birch Tree Lake, which is merely a broad, shallow section of the Burntwood River formed by natural erosion of these clay banks. Along the shores of the lakes and islands south of the Burntwood River, the clay cover is rarely more than 3 m thick.

Varved clays of alternating pale buff and black layers can be seen on Upper and Lower Ospwagan Lakes and in highway borrow pits. In places these laminated clays overlie a thin till horizon (Plate 19). On the south shore of Ospwagan Lake, and on a creek draining Mid Lake, the till is cemented by carbonates and/or iron oxides to the underlying bedrock.

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PLATE 1. Grey lit-par-lit gneiss (A1) containing white granitic mobilizate showing pinch-and-swell structure. Mid Lake area.

PLATE 2. Porphyritic meta-picrite (A2a). The distinctive pitted appearance results from weathering out of altered olivine phenocrysts. West shore of Upper Ospwagan Lake. (Chemical analysis (Sample No. 18-72-413) in Table 2).

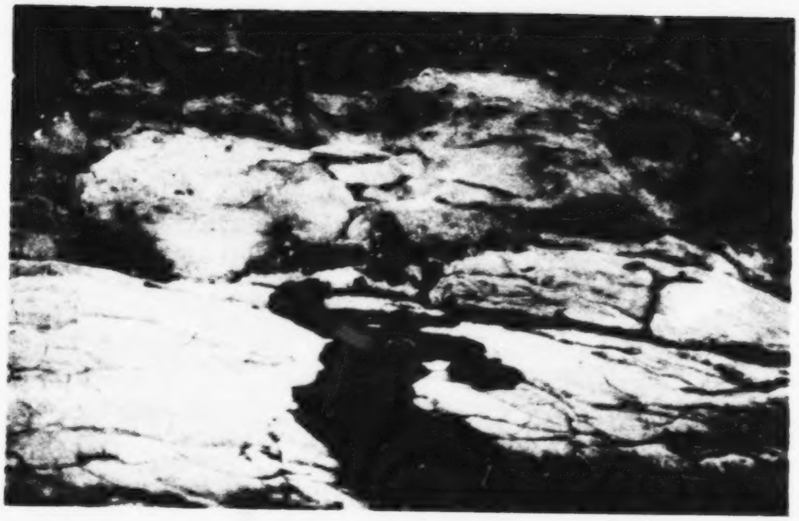


PLATE 3. Meta-picrite flow breccia (A2b). Deformed fragments are etched out on weathered surface. South shore of Lower Ospwagan Lake. (Chemical analysis (Sample No. 18-72-218) in Table 2).

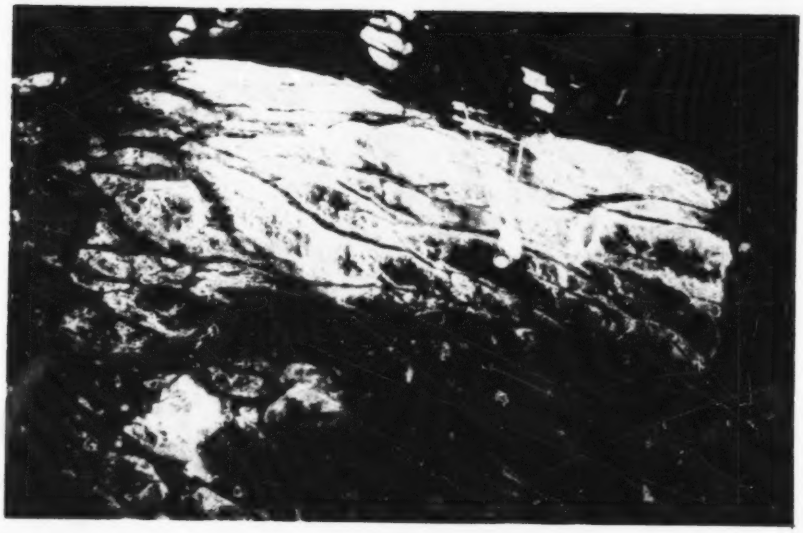


PLATE 4. Meta-picrite flow breccia (A2b) and/or possible pillow structures. Selvage-like margins seen on weathered surfaces. South shore of Lower Ospwagan Lake.

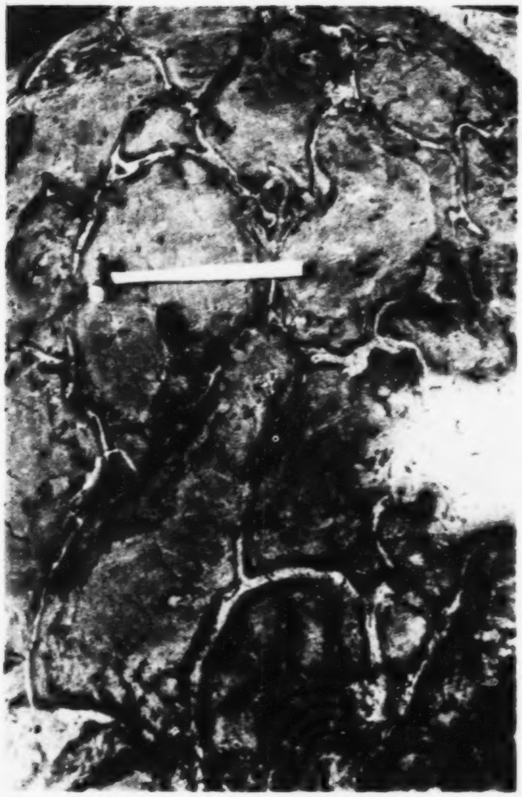


PLATE 5. Pillowed meta-basalt (A3) on small island near the south shore of Lower Ospwagan Lake. Pillows have been flattened perpendicular to their stratigraphic 'top' direction which is towards the upper edge of the photograph. (Chemical analysis (Sample No. 18-72-430) in Table 3).

PLATE 6. Mafic laminated tuff (A4b) containing thin white chert band. West shore of Niven Point.

PLATE 7. Meta-arkose (A5). North shore of Lower Ospwagan Lake.

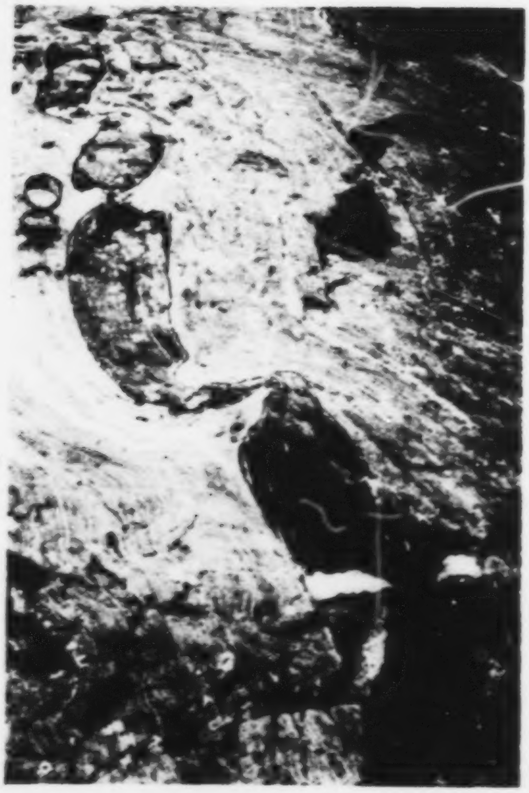


PLATE 8. Boudinaged amphibolite (A6a) in blastomylonite (A9b). Note partial rotation and slight discordance of the boudins. Reef exposure west of Niven Point.

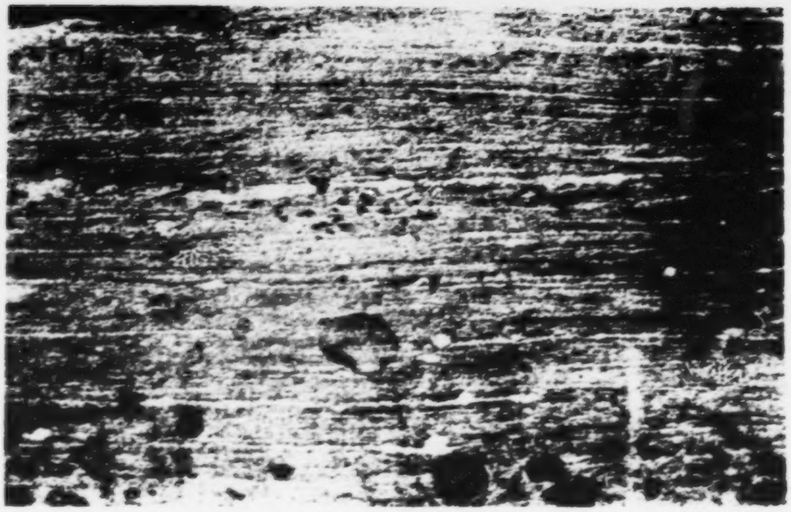


PLATE 9.

Mylonite gneiss (A9a) containing pale pink and white potassium feldspar porphyroelasts; southeast shore of Lower Ospwagan Lake.

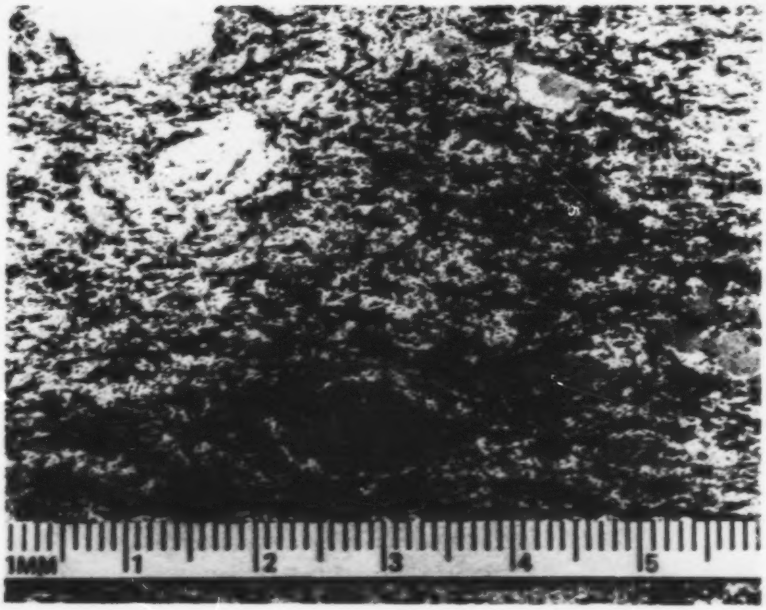


PLATE 10.

Mylonite gneiss (A9a). Stained slab showing potassium feldspar porphyroclasts (grey), plagioclase (white), mica and quartz (black). North shore of Lower Ospwagan Lake at entrance to Manasan River.

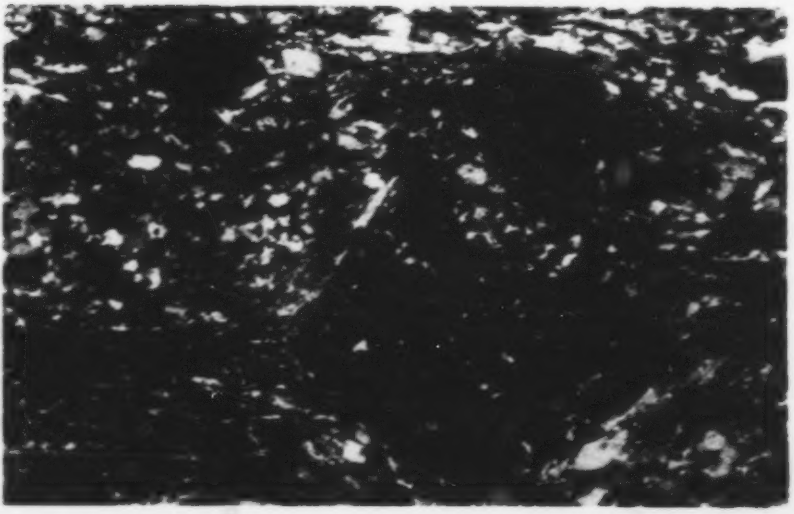


PLATE 11.

Mylonite gneiss (A9a). Photomicrograph of ovoid microcline porphyroclasts in a medium-grained recrystallized matrix of quartz, plagioclase and mica (crossed nicols). Note deflection of the foliation in the groundmass around the feldspar megacrysts. Midway between Taylor River and southwest shore of Upper Ospwagan Lake.

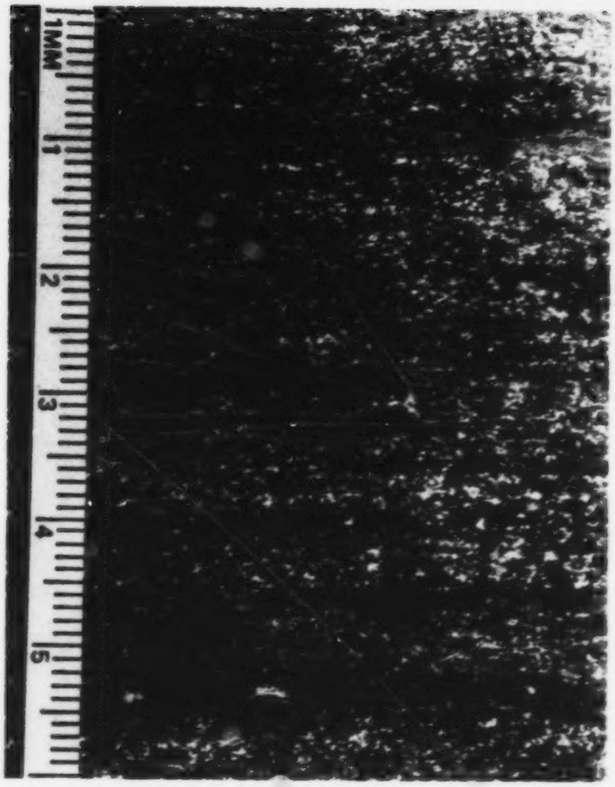


PLATE 12. Blastomylonite (A9b). Stained slab showing cataclastic foliation and small porphyroclasts (generally less than 0.5 mm in diameter). East shore of Lower Ospwagan Lake.

PLATE 13. Blastomylonite (A9b). Photomicrograph of ovoid feldspar porphyroclasts in fine-grained recrystallized matrix of quartz, plagioclase and mica (crossed nicols). Southwest shore of Niven Point.

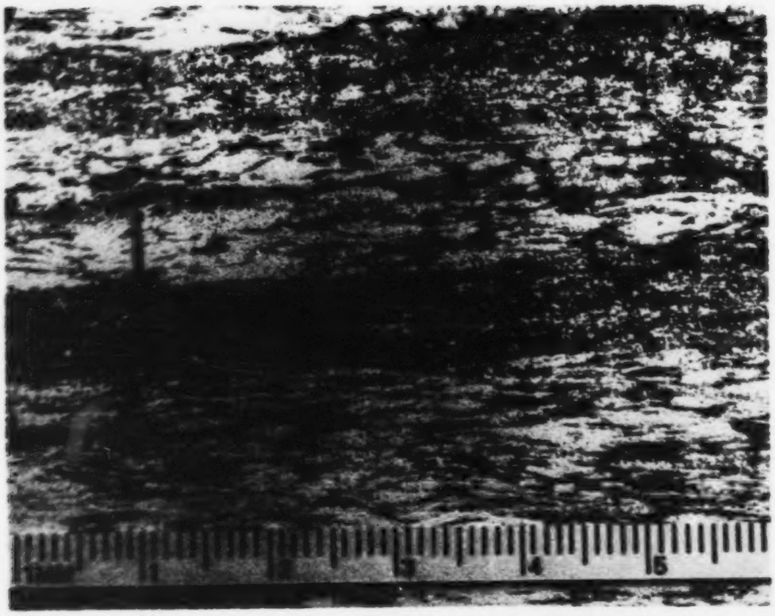


PLATE 14. Mylonite (A9c). Stained slab. Darker bands consist mainly of finely comminuted quartz and feldspar, interlayered with medium-grained mylonite gneiss. Northwest shore of Lower Ospwagan Lake.

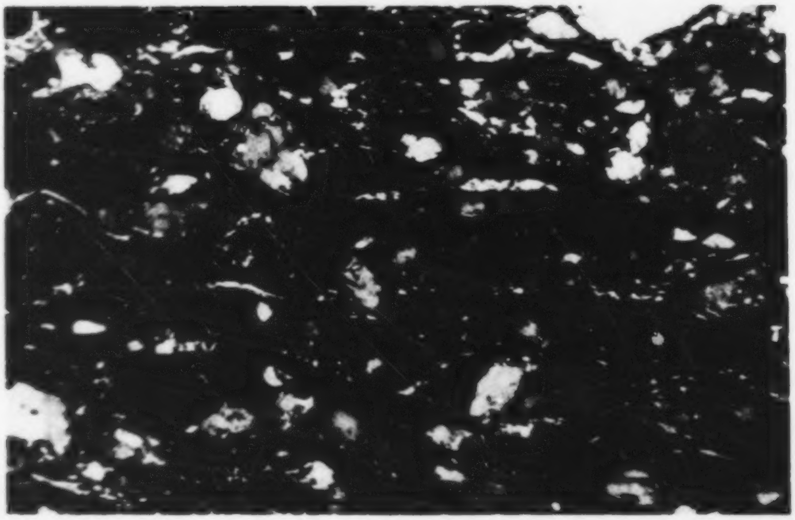


PLATE 15. Mylonite (A9c). Photomicrograph showing angular and ovoid grains of quartz and feldspar surrounded by finely crushed quartz, feldspar and mica (crossed nicols). West shore of small lake southwest of Upper Ospwagan Lake.

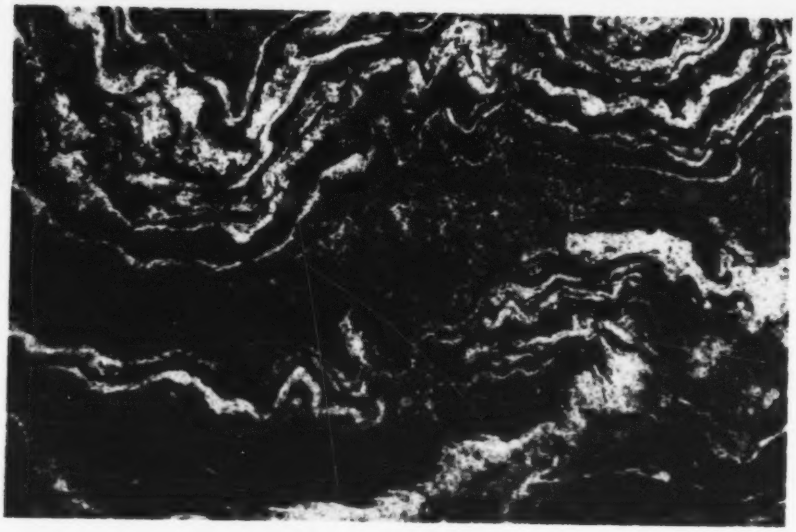


PLATE 16. Garnetiferous paragneiss (B1). Grey, medium-grained, plagioclase-quartz-biotite-garnet rock with interlayered white granodioritic mobilizate, displaying asymmetric flexural slip folding. North of Birchtree Brook, 6 km west of Birchtree Lake.

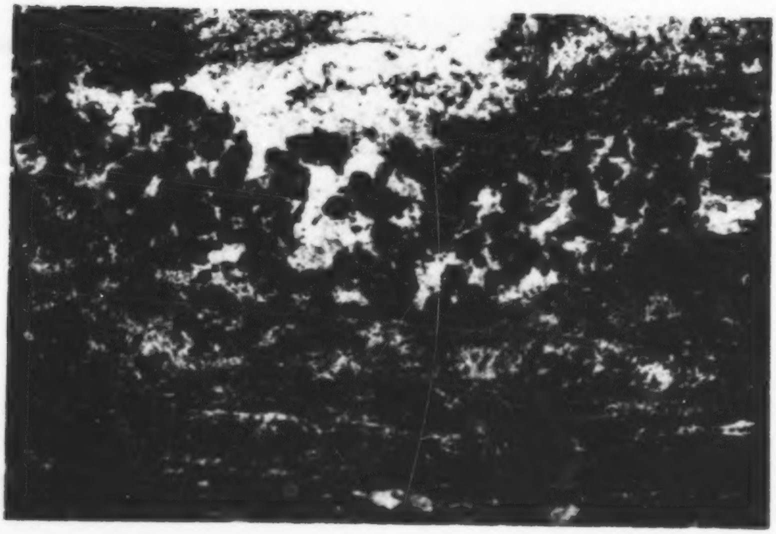


PLATE 17. Garnetiferous paragneiss (B1) containing pegmatitic mobilizate. The latter contains euhedral cordierite (grey) and garnet (dark grey) crystals, 1-2 cm diameter. Restite is grey, medium-grained plagioclase-quartz-biotite-garnet-cordierite-sillimanite gneiss. North boundary of map-area.

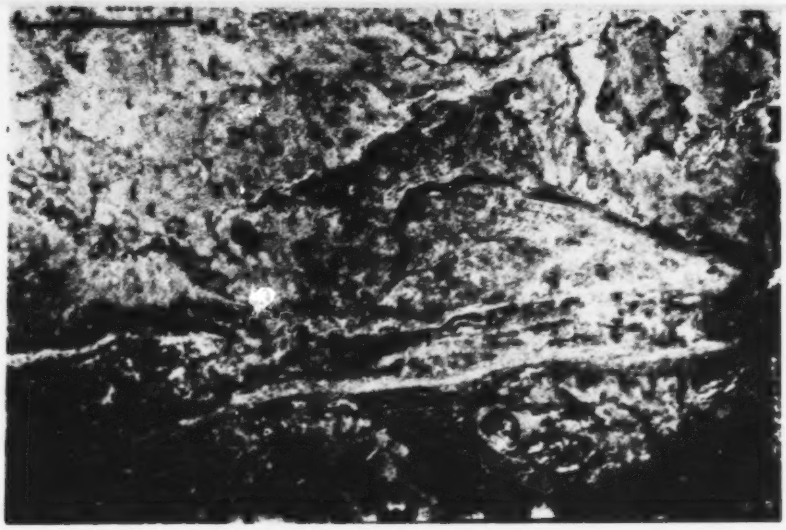


PLATE 18. Aerial photograph showing east end of moraine, north of Birchtree Brook. Visible on the photograph are narrow, discontinuous, parallel raised beaches on the slopes of the moraine.

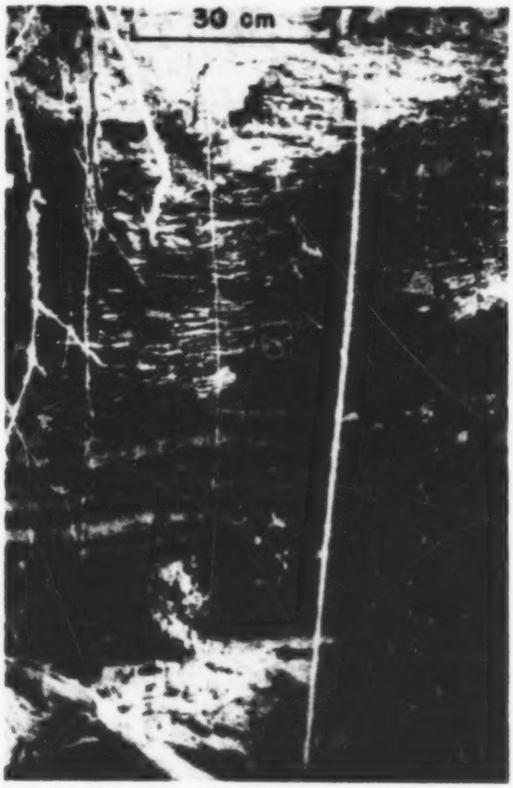
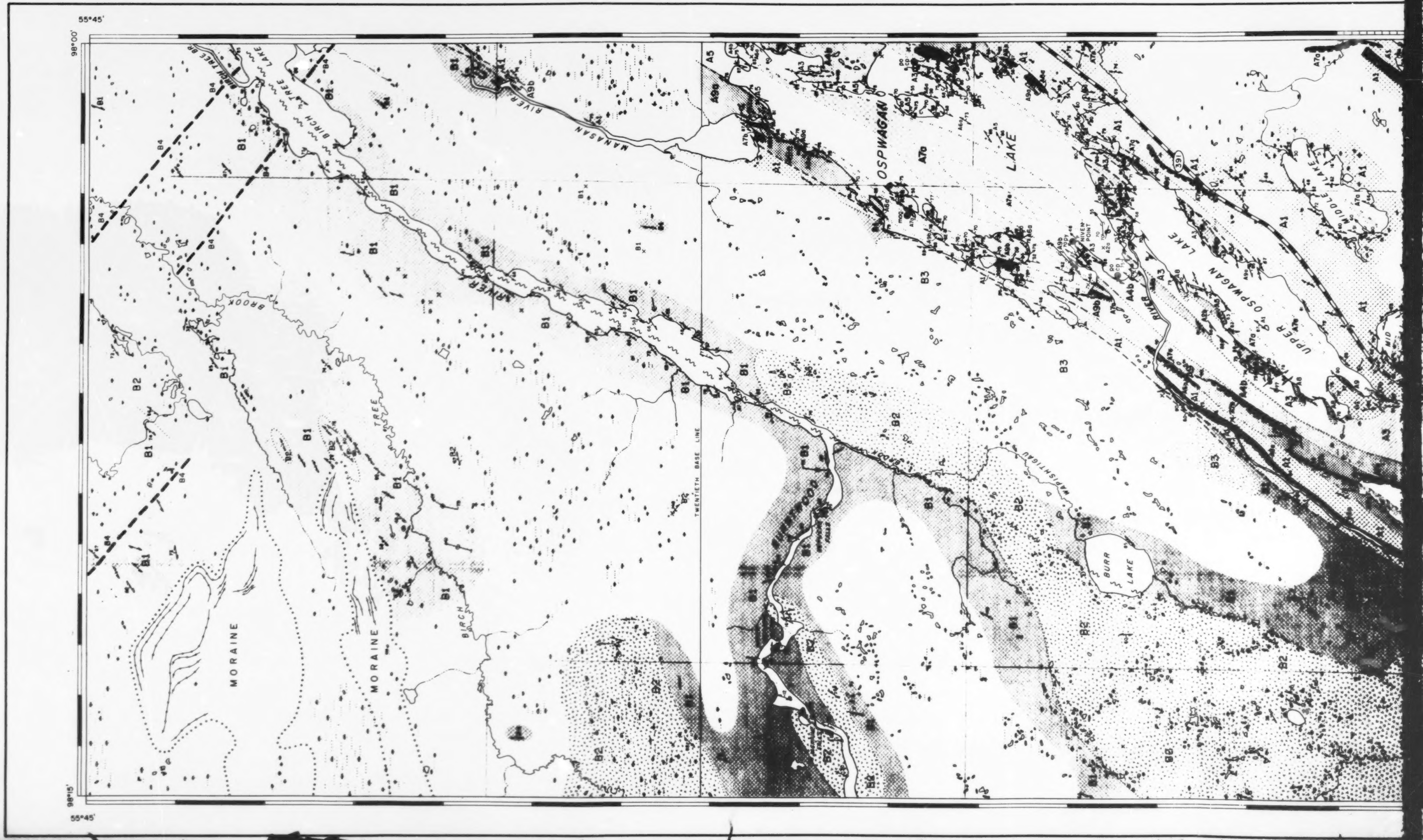
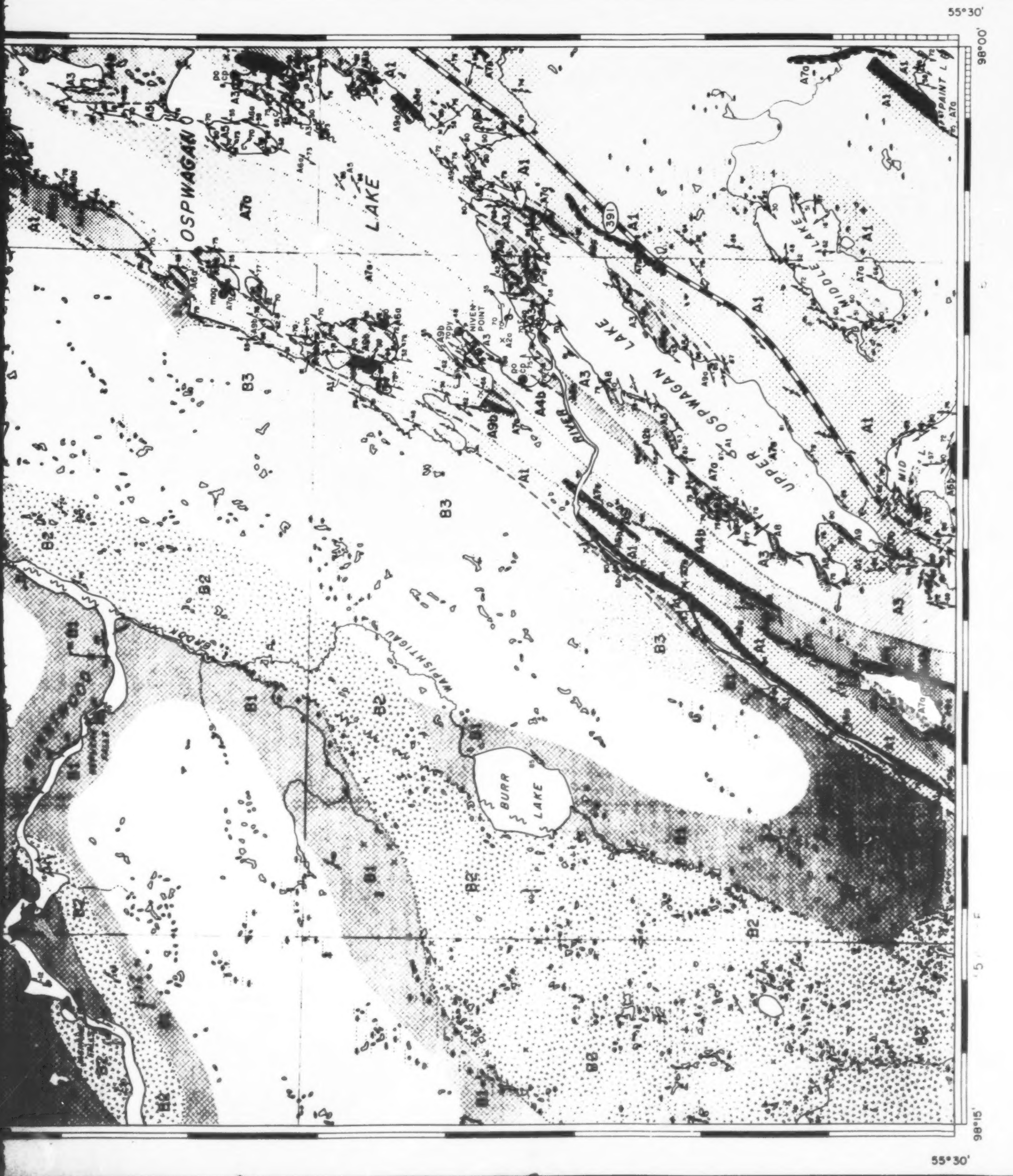


PLATE 19. Varved clays exposed in recently slumped bank on west shore of Upper Ospwagan Lake. Note sharp break in varve sequence and thin till deposit at the base.


55°45'
98°00'
98°15'
55°45'
BIRCH TREE BR
BIRCH TREE LAKE
MANASAN RIVER
OSPWAGAN LAKE
NIVEN POINT
UPPER OSPWAGAN LAKE
MIDDLE LAKE
391
RIVER
BIRCH TREE BROOK
BROOK
TWENTIETH BASE LINE
WAPISHTIGAU BROOK
BURR LAKE
MORAINE
MORAINE
A1
A3
A5
A7a
A9a
A9b
B1
B2
B3
B4


55°30'
98°00'
98°15'
55°30'
OSPWAGAN
LAKE
UPPER OSPWAGAN LAKE
MIDDLE LAKE
MID. L.
BURR LAKE
WAPISHTIGAU
RIVER
NIVEN POINT
391
A1
A3
A4b
A7a
A7b
A9b
B1
B2
B3

LEGEND

PRECAMBRIAN

Subarea B

B4	Diabase dykes (Mackenzie Swarm)
B3	Gneissic hornblende-quartz monzonite
B2	Gneissic biotite-quartz monzonite, granodiorite
B1	Grey garnetiferous biotite (-cordierite-sillimanite) paragneiss

Subarea A

A9a,b,c	a, Quartzo-feldspathic mylonite gneiss b, Blastomylonite c, Mylonite
A8	Granite pegmatite and aplite
A7a,b	a, Serpentinite and serpentinized peridotite b, Clinopyroxenite
A6a,b	a, Amphibolite b, Orthopyroxene garnet gneiss
A5	Meta-arkose and feldspathic quartzite
A4a,b	a, Meta-greywacke b, Mafic laminated tuff
A3	Pillowed meta-basalt
A2a,b	a, Porphyritic meta-picrite b, Meta-picrite flow breccia
A1	Grey *lit-par-lit* and porphyroblastic gneiss

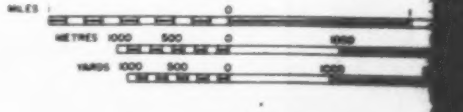
SYMB

× Small outcrop
Geological boundary
Geological boundary,
Igneous layering, pil
Metamorphic layerin
Gneissic foliation (in
Schistosity (inclined,
Cataclastic foliation
Minor folds:
axis (inclined)
axial plane (inclin
symmetry (asymm
S-shaped, symm
Mineral lineation (ho
Microcrenulation (inc
Boudin axis (incline
Deformed pillows (in
Fault (defined, appr
Mineral occurrence
py pyrite
po pyrrhotite
cp chalcopyrite
mag magnetite
Glacial striae (direc
Reef
Swamp
Moraine boundary
Raised beach
391 Provincial Road 391

OSPWAGAN LAK

THE PAS MININ

Scale 1:


MILES
0
METRES 1000 500 0 1000
YARDS 1000 500 0 1000

diorite

limonite) paragneiss

otite

eiss

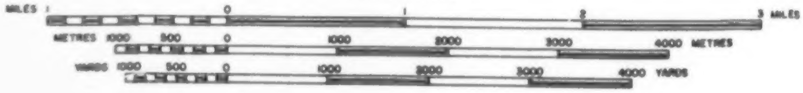
SYMBOLS

×	Small outcrop
— — — ········ ·· ··	Geological boundary (defined, approximate, assumed, underwater)
—·—·—	Geological boundary, gradational
60 50	Igneous layering, pillow tops known (inclined, overturned)
60	Metamorphic layering, *lit-par-lit* (inclined, vertical)
60	Gneissic foliation (inclined, vertical, dip unknown)
60	Schistosity (inclined, vertical)
60	Cataclastic foliation (inclined, vertical, dip unknown)
	Minor folds:
30	axis (inclined)
60	axial plane (inclined, vertical)
	symmetry (asymmetrical Z-shaped, asymmetrical S-shaped, symmetrical)
M M 30	Mineral lineation (horizontal, inclined)
C 30	Microcrenulation (inclined)
B 30	Boudin axis (inclined)
P 30	Deformed pillows (inclined)
∿∿∿ ∿∿ ∿∿	Fault (defined, approximate)
	Mineral occurrence:
● py	pyrite
● po	pyrrhotite
● cp	chalcopyrite
● mag	magnetite
	Glacial striae (direction of movement known)
+	Reef
	Swamp
• • • • • •	Moraine boundary
	Raised beach
391	Provincial Road 391

OSPWAGAN LAKE (East Half)

THE PAS MINING DISTRICT

Scale 1:50,000



LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

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